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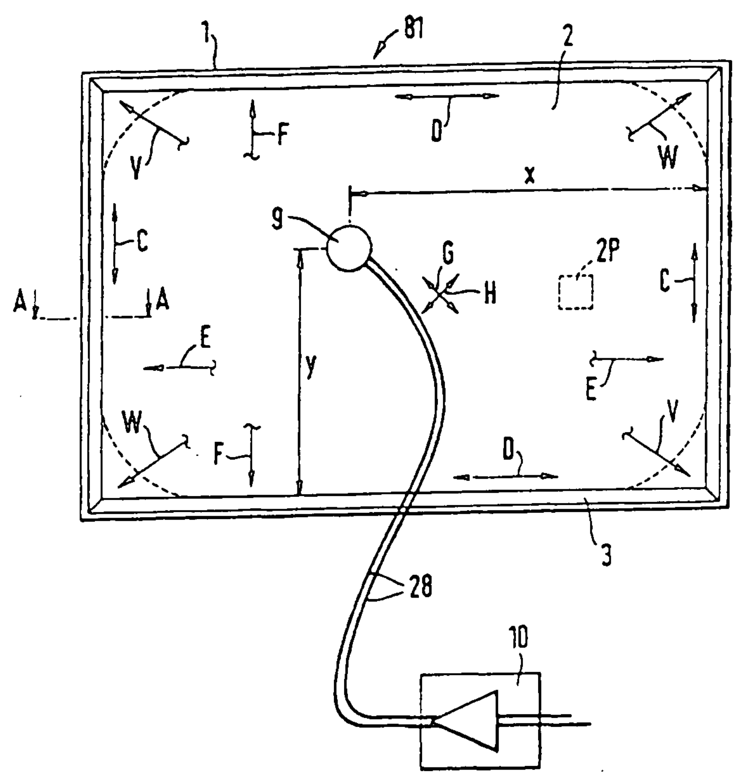
(54) Title: ACOUSTIC DEVICE

(57) Abstract

Acoustic device (81) including a member (2) extending transversely of its thickness and capable of sustaining bending waves at least over an intendedly consequentially acoustically active area of the transverse extent of said member, the member (2) having, by reason of orderly design methodology disclosed and claimed, a distribution of resonant modes of its natural bending wave vibration at least over said area that is dependent on values of particular parameters of said members, including geometrical configuration and directional bending stiffness(es), which values have been selected to predetermine said distribution of natural resonant modes being consonant with required achievable acoustic action of said member for operation of said device over a desired operative acoustic frequency range.



attached between the rear face thereof and the peripheral margin of the panel (2). A suitable transducer is as shown in Figure 24, i.e. of piezoelectric bender-on-disc type.

Particular device aspects of this invention include visual display apparatus comprising a notice or the like board in the form of a distributed mode acoustic radiator having a transducer mounted wholly and exclusively thereon to vibrate the radiator to cause it to resonate, thus be a loudspeaker which can be used to reinforce the visual information displayed thereon: where the radiator may comprise a stiff light-weight panel having a cellular core sandwiched between skin layers, a surrounding frame and a resilient suspension mounting the panel in the frame; the frame may have a return lip concealing the suspension; the skins may be of or may comprise paper and the core may comprise paper honeycomb; and the transducer may be a piezo electric bender.

Figure 53 illustrates packaging incorporating the loud-speaker technology hereof. The packaging is shown in the form of a box (111) having a hinged lid (139), the box, or at least part of it being made from a composite comprising a core of foamed plastics sandwiched between sheets of Kraft board to form a panel as shown in Figure 2, such that the box comprises a rigid, lightweight distributed mode acoustic radiator as described with reference to Figures 1 and 2. The rear panel (140) of the box is shown used to form a distributed mode radiator loudspeaker (81), although any one of the panels making up the sides of the box would be appropriate if suitably constructed. An alternative placement for the transducer (9) is shown in dotted lines.

A piezoelectric transducer (9) can be as shown in more detail in Figure 24, and is illustrated attached to the inner face of the rear panel (140) of the box and is driven by a sound generator/amplifier/ battery unit (112) also mounted on the rear panel. The unit (112) is controlled by

a switch formed integrally with a hinge (53) by which the lid (139) is secured to the box, whereby the sound generator is activated when the lid is lifted. In this arrangement the edge termination of the panel (2) is formed by the corners of the box so that no additional frame (1) or suspension (3) of the kind shown in Figures 1 and 2 is required. It will be appreciated that the packaging need not be of the shape shown in the drawing, and could, for example, be shaped according to the requirements of the contents. Thus the packaging might be shaped to enclose a compact disc or the like and may be arranged to preview the contents of the compact disc or to provide other information relating thereto.

Particular device aspects of this invention include packaging comprising a board component comprising a distributed mode acoustic radiator having a transducer mounted wholly and exclusively on the radiator to vibrate the radiator to cause it to resonate; where the board may be a panel having a cellular core sandwiched between skin layers, typically a core of foamed plastics sandwiched between sheets of Kraft board; the transducer may be a piezo-electric bender, and the board may form one side of a box, which may have a lid; and means may be associated with the lid for triggering actuation of the transducer on movement of the lid relative to the box. The packaging may further comprise a signal generator, an amplifier and an electric battery.

Figure 54 shows a greetings or similar card (44) incorporating loudspeaker technology hereof. The card is in the form of a folded member having a front leaf (145) and a rear leaf (146). At least the rear leaf (146) is made from a composite board consisting of a core (22) of foam plastics sandwiched by skins of Kraft board (21) to form a rigid lightweight distributed mode acoustic radiator panel (2) of the kind described in Figures 1 and 2. Such composite boards are known under the trade name KAPPABOARD. It has been found that a panel shaped according to the Euro-

pean standard 'A' series is suitable. A transducer (9) as shown in Figure 24 is attached to the rear leaf (146) to vibrate the panel (2) to cause it to resonate to produce an acoustic output. The transducer (9) is driven by a signal generator/amplifier/battery unit (112) which is actuated by a switch (53) concealed in the fold of the card so as to activate the signal generator when the card is opened. It will be noted that in this arrangement, no frame (1) or surround (3) is required. Sufficient damping of the card is provided either by the material from which the card is constructed and/or by holding the card or standing it on a surface.

Particular device aspects of this invention include a greetings or the like card having or comprising a board forming at least part of the card, the board being a distributed mode acoustic radiator having a transducer, preferably of piezo-electric bender type say a crystalline disc, mounted wholly and exclusively on the radiator to vibrate the radiator to cause it to resonate, the board preferably being a panel having a cellular core sandwiched between skin layers, say a core of foamed plastics sandwiched between sheets of Kraft board. Such board may form a leaf of the card, which may have a pair of leaves, preferably with associated means for triggering actuation of the radiator on movement of one leaf relative to the other leaf; and a greetings or the like card may comprise a signal generator, an amplifier and an electric battery on a leaf of the card.

Figure 55 shows a multi-media audio-visual system comprising a moving picture projector (31) arranged to project an image onto a projection screen formed by a loudspeaker panel (32) of the kind shown in Figures 1 and 2. The latter (32) comprises a panel (2) having aluminium or carbon fibre reinforced skins (21) sandwiching a honeycomb core (22) of aluminium foil. The composite may be secured together using any epoxy adhesive. For a screen panel size of 1.22 x 1.38m, the thickness of the aluminium

skins may be 300 microns. The core thickness may be 11mm and the cell size of honeycomb may be 9.5mm. Such a panel is stiff, of low density, high modulus and is substantially isotropic as to bending stiffness.

A pair of smaller subsidiary loudspeakers (114) of the kind described in Figures 1 and 2 are hinged on opposite sides of the centre channel loudspeaker panel (32) by means of hinges (34) whereby the subsidiary panels can be hinged against the primary panel (32) when not in use and can be moved into the position as illustrated for use. The subsidiary panels (114) are arranged to receive and radiate respective left and right hand channel information, e.g. for stereo operation. The subsidiary loudspeakers (114) may comprise panels (2) having skins (21) of aluminium foil, or carbon fibre or glass fibre reinforced plastics. A decorative film, e.g. of Melanex, may be applied over one or both of the skins. The core (22) of the panels (114) may be of aluminium foil, e.g. in a honeycomb cell arrangement, or may be of paper cells. Where paper is employed it may be impregnated with a plastics material such as a phenolic compound to improve the stiffness of the paper. The cell size may be in the range 3 to 6mm and the core thickness may be of the order of 3 to 10mm. Where the skins are of aluminium foil they may be 25 to 100 microns in thickness. An epoxy adhesive may be used to assemble the panel.

Stereo, i.e. two-channel sound reproduction, involves the creation of sound stage illusion containing the properties of source location, perspective and the ambience of the original recording. Stereo with conventional speakers is strong on aspects of phantom source location and in some cases perspective, but is weaker in respect of the expression of natural space and ambience. This is because the near point source nature of conventional pistonic speakers makes it easy aurally to identify their physical location, which in conflict with the desire for overall stereo image localisation.

It is often said that as reproducing devices the loud-

speakers should disappear into the sound stage illusion. Part of the problem lies in the relatively narrow forward radiating directivity of conventional speakers. Additionally, the sound balance to the sides and rear of the enclosure, sound which strongly drives the reverberant sound field in the room, is coloured and unbalanced with significant variations in frequency response. This detracts from the sense of natural acoustic space and ambience.

The embodiment of Figure 55 employs a pair of acoustic panel speakers for left and right channels which are set in complex vibration over the whole surface over a wide frequency range typically 100Hz to 20kHz. The central/primary loudspeaker panel (32) is shown suspended on suspension means (33) but alternatively the panel may be supported e.g. on a floor stand.

Figure 57 shows how the projection apparatus may be arranged in a room (145) equipped with seating (146). The apparatus has a projector (31) projecting an image onto the screen (32) and also includes a pair of subwoofers (35), which may be of conventional construction, at the sides of the room to improve bass audio extension and a pair of rear effect loudspeakers (117) i.e. so-called ambience speakers, at the rear of the room. Suitably the rear speakers (117) are also of the kind shown in Figures 1 and 2 in view of their wide and even sound dispersion characteristics. The rear effect loudspeakers may be of the same construction as the subsidiary loudspeakers (114).

A distributed mode panel loudspeaker hereof can have remarkable non-directional properties. For acoustic reproduction of ambience channels of a sound system, the energy must be widely distributed, ideally from non-directional sources. It is important that the sound source is not well localised otherwise the perception of a large ambient space, the simulated acoustic region behind the listener, is unsatisfactory.

Hitherto conventional directional and/or small source speakers, generally moving coil types, have been used for

ambience reproduction. Due to the intensity phenomenon of aural perception, audience members seated closer to a nearby ambience speaker find their perception strongly localised on that speaker greatly impairing the ambience effect and their whole appreciation of the multichannel sound field. The localisation may be so powerful that aural attention is drawn away from the primary front stage sound channels.

An ambience reproducing system built with one or more loudspeakers according to the teachings hereof deliver a large sound field or near uniform intensity which has deliberately poor localisation. A large audience may be handled, even with some persons in close proximity (as near as 0.5m) to the panel loudspeakers without any significant localisation of the immediate reproducing channel and with the vital property of an unimpaired aural perception of the important front channels. Greatly improved realism is achieved for the multi-channel sound reproducing system as a whole as a result of the desirable radiating characteristics of the acoustic panel sound reproducer. The ambience loudspeakers may if desired be suspended on wires and disguised, by the application of a suitable image to the panel (2) to resemble pictures.

Figure 56 shows how the frames (1) of the projection/loudspeaker panel may be formed with a return lip (36) whereby the suspension (3) can be concealed. The frames of the subsidiary loudspeakers (114) and the ambience loudspeakers (117) may be similarly formed.

Particular device aspects of this invention include a projection screen comprising a panel having a light reflective surface, wherein the screen is a distributed mode acoustic radiator having a transducer mounted wholly and exclusively thereon to vibrate the radiator to cause it to resonate; the radiator preferably comprising a stiff lightweight panel having a cellular core sandwiched between a pair of high modulus skins, a surrounding frame, and a resilient suspension mounting the panel in the frame, the

cellular core preferably being of honey-comb aluminium foil, and the skins preferably being of fibre-reinforced plastics: and/or as the projection screen comprising panel-form loudspeakers attached to opposite sides thereof to provide left and right hand channel information, say left and right hand loudspeakers being hinged on the radiator to be foldable against the radiator for storage, preferably themselves as distributed mode acoustic radiators each having a transducer mounted wholly and exclusively thereon to vibrate the radiator to cause it to resonate: and/or as audio visual apparatus characterised by a projection screen as aforesaid and/or the audio-visual apparatus comprising at least one rear channel loudspeaker in the form of a distributed mode acoustic radiator having a transducer mounted wholly and exclusively thereon to vibrate the radiator to cause it to resonate.

Such an acoustic panel built to sufficient size to serve as a projection screen for still, film and video images, is thus simultaneously a sound reproducer, with advantage as the centre or dialogue channel of home theatre equipment, and an acoustic panels hereof having good size, say over 0.6m wide, and providing very good sound coverage for audiences. Working demonstrations have shown high intelligibility and sound clarity over the whole audience region with a major advantage that persons nearest to the screen do not suffer blasting from excessive proximate sound levels, invariably a flaw of conventional direct radiating cone based speakers.

Moreover, another inventive aspect of a projection screen hereof arises in relation to conventional centre channel speakers and the ear's readiest tendency for locating the acoustic centre of a cone/diaphragm loudspeaker, so that all sounds appear to come from such concentrated small source, thus detracting from the sense of realism; whereas, for an acoustic panel hereof, its uniquely non-directional radiation property means that the sound appears to come from the general acoustic region of the screen but

not from one isolated point, so that, when the image is accompanied with sound on the panel, there is a powerful synaesthetic effect, in that lack of specific sound source localisation allows the ear/brain sound-sensing combination freely to associate an imagined, virtual and undefined/approximate location for sound sources sensorally to appear to be synchronised and/or registering with locations presented by the visual image on the acoustic surface, e.g. mentally relating voices quite closely and accurately to mouths and faces. With well recorded dialogue sections, not only does a virtual or perceived acoustic image appear to track the actual visual image, but can also serve to convey the information needed for the perception to depth/perspective, so that the quality of audience involvement in the cinematic experience is substantially enhanced.

Slotting (38) for edges of resonant mode panel members hereof, see Figure 58, can also be useful in dealing with improving uniformity of bending wave action, and/or generally for controlling particular frequencies by affecting relevant resonant modes.

In relation to any desired further correction, or composition of desired frequency-related response, perhaps particularly at low or high frequency ends of operating range, say if coincidence frequency is included either at such end or medially, electronic input signal processing for a loudspeaker hereof can be provided.

Figure 59 shows simple input signal bandwidth control through capacitor (77) and resister capacitor (78,77) amplifier (10) circuits (Figures 59a,59b) for piezoelectric transducers (9, Figure 59a; 79, Figure 59d) including assessing to a required range response (96, Figure 59c).

Further sample passive equalizer circuitry (compared with normal core-type cross-over networks) is indicated in Figure 60a (using amplifier 10 with parallel LCR network 113, 77, 78) and Figure 60c (parallel resistor-capacitor circuit (78, 77)) relative to particular frequency response requirements (Figures 60b, 60d) perhaps of particular rel-

evance to dealing with included coincidence frequency effects.

Areal curving of resonant panel members hereof has been mentioned in relation to affecting bending stiffness in the dimension of the panel member concerned. However, there can be other desiderata or requirements for curved loudspeakers, or microphones, or passive reverberation, filtering or voicing panels, say unobtrusively to fit to curved surfaces, such as columns. Figure 61 indicates use of curved resonant panel loudspeakers (55), or as repeaters or satellites, that demonstrate diffusion (Figure 61a), focussing (Figure 61b) and application in a listening room involving forward focussing loudspeakers, typically for defining stereo with diffusion (57) behind them, and rearward diffusing loudspeakers, typically for improving ambience.

As to full five channel home theatre ambience systems, such as achievable using resonant panel loudspeaker hereof, including the screen (118) itself as the centre channel and any desired sub-woofers (35). However, particular merit is seen in systems where perhaps only rearward ambience loudspeakers are of resonant panel type, see 117 or Figure 62, perhaps because conventional core-type forward stereo loudspeakers (42) are, for some reason, actually preferred.

Turning to use of panel members hereof purely as passive acoustic devices, Figure 63 shows voicing for a small theatre or dance studio; and Figure 64 shows use in mounting such as a Hi-Fi unit (46), say as a base (44) shown on pads or feet (45). Figure 65 shows use as structural panels (44) of an enclosure for conventional core-type (42) loudspeaker units, and can be highly successful as to giving minimum colouration and/or even correcting room or other colouration if "varied" appropriately. Figures 66a and 66b show a panel (22) used as an upright piano sounding board (47) mounting backing onto its stringed frame 108, with fixing by studs 107 that can have a clamping or only a just retaining action, it being the case

that holes through panels hereof need not be deleterious if in appropriate calculable positions, even can be beneficial in relation to specified modal frequencies. It would be feasible to so mount with good location, but no unwanted effects on vibrational performance.

Figure 67 concerns manufacture from the point where stock sheet for the cores (22), which is in a size from which several panel members (2) can result, has at least one skin applied (lower in Figure 67b); and the other skin (21) is applied (upper in Figure 67a) over as much as desired up to the whole of the core sheet after the transducers (9) are installed, conveniently along with printed wiring track (122) and transducer lead wiring (28), advantageously connected up for reeling out, before the upper of the skins (21), and fixing into shallow indenting of the core stock material. Movement shown by arrow (125) allows guillotining (124) at one desired panel dimension (length) and the other (width) can be set by width of the stock core material or by splitting as shown and leading to highly effective mass production. The panel member dimensions (length/width) are, of course, as readily determined in practising methods hereof, including for other than rectangular shapes to be finished from rectangular precursors that correspond with relevant aspect ratio determined as herein.

INDUSTRIAL APPLICABILITY

Embodiments of this invention have the same and more uses and applications than the ubiquitous conventional cone-type loudspeakers.

CLAIMS

1. Method of making an acoustic device to include a member extending transversely of its thickness and capable of sustaining bending waves at least over an intendedly consequentially acoustically active area of the transverse extent of said member, the method including analysis of distribution of resonant modes of natural bending wave vibration of said member over said area, said distribution of natural said resonant modes varying according to values of particular parameters of said member; and selecting values of said parameters resulting in said distribution of natural resonant modes being consonant with required achievable acoustic action of said member for operation of said device over a desired frequency range; and making, as at least a component of said device, a said member with said selected values of said parameters.

2. Acoustic device including a member extending transversely of its thickness and capable of sustaining bending waves at least over an intendedly consequentially acoustically active area of the transverse extent of said member, the member having a distribution of resonant modes of its natural bending wave vibration at least over said area that is dependent on values of particular parameters of said members, which values have been selected to predetermine said distribution of natural resonant modes being consonant with required achievable acoustic action of said member for operation of said device over a desired operative acoustic frequency range.

3. Method or acoustic device according to claim 1 or claim 2, wherein said parameters are associated with at least two different directions through said area of said member.

4. Method according to claim 1, 2 or 3, wherein said analysis involves assessing parts or subareas of said area for content of vibrational energy from predetermined said natural resonant nodes; and said selecting is so as to reduce incidence of low vibrational energy contents of said

parts or subareas.

5. Method according to claim 4, wherein said reducing is to minimise incidence of low vibrational energy contents of said parts or subareas.

6. Method according to any preceding claim, wherein said analysis involves assessing parts or subareas of said area for content of vibrational energy from predetermined said natural resonant modes, and said selecting is as to producing more even spread of vibrational energy contents of said parts or subareas.

7. Method of making an acoustic device to include a member extending transversely of its thickness and capable of sustaining bending waves at least over an intendedly acoustically active area of its transverse extent involving acoustically relevant resonant modes of its natural bending wave vibration which has a characteristic distribution over said area of vibrationally more or most active regions and vibrationally less or least active regions that is dependent on values of at least two particular parameters of said member, the method comprising analysis of less or least and more or most vibrational activity in said regions, and selecting values corresponding to a said distribution in which regions of low or no vibrational activity are reduced towards optimum practical for further corresponding with desired achievable acoustic operation of said device; and making, as at least a component of said device, a said member with said selected values of said parameters.

8. Acoustic device comprising a member extending transversely of its thickness and capable of sustaining bending waves in an intendedly acoustically operative area of its transverse extent involving acoustically relevant resonant modes of its natural bending wave vibration which has a characteristic distribution over said area of vibrationally more or most active regions and vibrationally less or least active regions that is dependent on values of at least two particular parameters of said member, wherein said member has selected values of said parameters predetermined to

give a corresponding said distribution in which regions of low or no vibrational activity are reduced towards optimum practical for further corresponding with desired achievable acoustic operation of said device.

9. Method or acoustic device according to any one of claims 4 to 9, wherein one set of said resonant modes and corresponding contributions to said distribution are particularly affected by at least one of said parameters and another set of said resonant modes and corresponding contributions to said distribution are particularly affected by another of said parameters, the selected values of said one and other parameters corresponding to said contributions of said one set to said vibrationally more or most active regions being as complementary as practically achievable relative to said contributions of said other set to said vibrationally less or least active regions, and *vice versa*.

10. Method according to any preceding claim, wherein said analysis involves assessing frequencies of said resonant modes for spacings of their values, and said determining is as to achieving optimum practical spacings of those frequencies.

11. Method or acoustic device according to any preceding claim, wherein said parameters can be related to at least two different conceptual frequencies to which frequencies of said resonant modes can themselves be related.

12. Method of making an acoustic device having a member extending transversely of its thickness and capable of sustaining bending waves in an acoustically operative area of its transverse extent involving operatively relevant resonant modes of its natural bending wave vibration that can be related to at least two conceptual frequencies that are dependent on values of at least two particular parameters of said member, the method comprising analysis to determine selected values of said parameters to give values of said conceptual frequencies thus related said resonant modes at frequencies that are spaced and inter-leaved beneficially to achieving desired acoustic operation of said

device; and making, as at least a component of said device, a said member with said selected values of said parameters.

13. Acoustic device comprising a member extending transversely of its thickness and capable of sustaining bending waves in an acoustically operative area of its transverse extent involving operatively relevant resonant modes of its natural bending wave vibration that can be related to at least two conceptual frequencies that are dependent on selected values of at least two parameters of said member, wherein said member has values of said parameters predetermined to give values of said conceptual frequencies thus indicate said resonant modes at frequencies that are spaced and inter-leaved beneficially to achieving desired acoustic operation of said device.

14. Method or acoustic device according to any one of claims 10 to 13, wherein said selected parameters assure that said conceptual frequencies are so related that there is inter-leaving of said resonant mode frequencies with spacings and consequent spread at or approaching optimum for non-coincidence and even-ness of such spread.

15. Method or acoustic device according to any one of claims 10 to 14, wherein said conceptual frequencies are each definingly affected by said selected values of different said parameters.

16. Method or acoustic device according to any preceding claim, wherein said selected values are of corresponding said parameters relating to geometrical configuration or shape and/or to bending stiffnesses in different directions.

17. Method or acoustic device according to any preceding claim, wherein said selected values are of corresponding said parameters of a similar nature and selectable by a mutually relative value, such as a ratio or a relative percentage.

18. Method or acoustic device according to claim 16 or 17, wherein geometrical said corresponding parameters define shape of at least said area of said member for given bend-

ing stiffness(es) of said member through said area.

19. Method or acoustic device according to claim 18, wherein said selected values of said geometrical parameters specify a particular variation of a basic shape according to dimensions in different directions across said shape.

20. Method of making an acoustic device including the step of determining geometrical configuration of a member extending transversely of its thickness in its area to be configured, said member being capable of sustaining bending waves at least over said area, the method including analysis of distribution of resonant modes of natural bending wave vibration of said member, which distribution will be different for different said configurations of said area as variably defined by relevant geometrical parameters, and selecting a particular relative value of said parameters for which said distribution of natural resonant modes is determined as being consonant with desired achievable acoustic device action or operation over a frequency range of interest; and making as a component of said device a said member having its said area configured to said particular relative value of said geometrical parameters.

21. Acoustic device including a member extending transversely of its thickness over an area of predetermined geometrical configuration, said member being capable of sustaining bending waves at least over said area, at least said area being configured to predetermine distribution of resonant modes of natural bending wave vibration of said member by a selected particular relative value of geometrical parameters defining said configuration and consequent said distribution of natural resonant modes consonant with desired achievable acoustic device action or operation over a frequency range of interest.

22. Method or acoustic device according to claim 20 or claim 21, wherein said geometrical parameters include dimensions in different directions across said area.

23. Method of making an acoustic device having a member extending transversely of its thickness and capable of

sustaining bending waves, the method comprising analysis to define a geometrical configuration of said member determining at least two conceptual frequencies relatable to frequecies of resonant modes of natural bending wave vibration over its area, which conceptual frequencies have a mutual relationship such that predetermined lower frequency resonant modes relatableto said conceptual frequencies are correlated by at least some of vibrationally more or most active regions of said area of those said modes related to one of said conceptual frequencies being shared by or corresponding to vibrationally less or least active regions related to those modes of the other of said conceptual frequencies; and making, as at least a component of said device, a said member having at least its said area configured to said particular relative value of said geometrical parameters.

24. Acoustic device comprising a member extending transversely of its thickness and capable of sustaining bending waves, wherein the member has a geometrical configuration determining natural bending wave vibration over its area with resonant modes relatable to at least two conceptual frequencies, and a relationship between said conceptual frequencies such that predetermined lower frequency resonant modes arising from said conceptual frequencies are correlated by at least some of vibrationally more or most active regions of said area for those said modes related to one of said conceptual frequencies being shared by or corresponding to vibrationally less or least active regions rel-ated to those said modes of the other of said conceptual frequencies.

25. Method or acoustic device according to claim 23 or claim 24, wherein dimensions of said member determining said conceptual frequencies are in different directions across said area.

26. Method or acoustic device according to claim 22 or claim 25, wherein said directions are substantially mutually perpendicular.

27. Acoustic device according to claim 26, wherein said area is of substantially rectangular shape with length and width as said geometrical parameters or dimensions.

28. Acoustic device according to claim 27, wherein said substantially rectangular area has substantially equal bending stiffnesses along its length and width, which are unequal dimensionally by about 13.4% or about 37%.

29. Acoustic device according to claim 27 or claim 28, wherein said area is short of true rectangle corners for at least one diagonal dimension by an amount beneficially relating attributable resonant modes to those arising from length and width dimensions.

30. Acoustic device according to claim 29, wherein said amount is between about 10% and about 15% for diagonal bending stiffness(es) not differing substantially from bending stiffness(e) in the length and width directions.

31. Acoustic device according to claim 27 or claim 28, wherein said substantially rectangular area has diagonal bending stiffness(es) different from bending stiffness(es) in the directions of its length and width by an amount beneficially relating attributable resonant modes to those arising from its length and width dimensions.

32. Acoustic device according to claim 26, wherein said area is of substantially true elliptical shape with its major and minor axes as said geometrical parameters or dimensions.

33. Acoustic device according to claim 32, wherein said member has substantially equal bending stiffnesses along its major and minor axes, which are dimensionally unequal by of about 18.2% or about 34%.

34. Acoustic device according to claim 26, wherein said area is of substantially super-elliptical shape with its major and minor axes as said geometrical parameters to be determined dimensionally for any particular super-ellipse defining power factor(s).

35. Acoustic device according to claim 34, wherein said area is of substantially super-elliptical shape with its

super-ellipse defining power factor to be determined for any particular relative dimensional value(s) of its major and minor axes.

36. Acoustic device according to claim 34 or 35, wherein said member has substantially equal bending stiffnesses along said major and minor axes, which are dimensionally unequal by of about 13% to about 22%, or about 32%, and said defining power factor is about 3.5 to about 4.

37. Acoustic device according to claim 26, wherein said member is of composite shape and has substantially equal bending stiffnesses along and transversely of a common major axis for parts of said area substantially corresponding to super-elliptical and true elliptical, respectively, merged with said common major axis with said elliptical part favoured by about 1.1-1.3:1, and an aspect ration of favouring said common major axis by about 1.2:1.

38. Acoustic device according to claim 19, 22, 25-27, 29-32, 34 or 35, wherein said member has different bending stiffnesses in said directions, and said dimensions are such as to give as near as is practicable substantially equivalent results for said resonant modes as achieved for substantially equal bending stiffness(es) in said directions, including any appropriate scaling.

39. Acoustic device according to claim 38, wherein said equivalent results include relationship of conceptual frequencies to which said resonant modes of interest are relatable.

40. Method of making an acoustic device using a member of given geometrical configuration extending transversely of its thickness and capable of sustaining bending waves over its area, the method including analysis to determine values of geometrical parameters in respective ones of two directions across said area that contribute with corresponding bending stiffnesses of said member to deriving conceptual frequencies relatable to natural bending wave vibration of said member being as useful as practicable within said area for achievable acoustical action of part of said member

relative to desired performance of said device, and determining corresponding bending stiffnesses in said directions, and defining said part as an acoustically operative area by way of means limiting passage of bending waves in said member beyond said limiting means; and making, as at least a component of said device, a said member with limited said operative area.

41. Method of making an acoustic device having a member extending transversely of its thickness in an area of desired geometrical configuration and capable of sustaining bending waves over said area, the method including analysis using geometrical parameters that define said desired geometrical configuration in respective ones of two directions across said area and contribute with corresponding bending stiffnesses to deriving conceptual frequencies relatable to natural bending wave vibration of said member in said area, ascertaining said conceptual frequencies that correspond with desired acoustical action of said member and performance of said device, and determining corresponding bending stiffnesses in said directions; and making, as at least a component of said device, a said member of materials and structure aff-ording said bending stiffness in said geometrical configur-ation.

42. Acoustic device comprising a member extending transversely of its thickness and capable of sustaining bending waves over its area, wherein the member has a geometrical configuration with unequal overall bending resistances in directions determining at least two conceptual frequencies relatable to natural bending wave vibration over said area and resonant modes arising for natural bending wave vibration in said member that are consonant with desired acoustic action or performance of said device.

43. Method according to any preceding claim, wherein said analysis involves only predetermined said resonant modes that are low rather than high in said frequency range.

44. Method according to claim 43, wherein said predetermined resonant modes include more than twenty above natural

fundamental and related conceptual frequencies further relatable to said natural bending wave vibration of said member.

45. Method according to claim 44, wherein said predetermined resonant modes include the first twenty-five or more above said natural resonant frequencies.

46. Method or acoustic device according to any preceding claim, wherein the or each said member has damping means selectively applied thereto as predetermined to control frequencies corresponding to one or more said resonant modes.

47. Method or acoustic device according to claim 46, wherein said selective damping means includes damping attachments at medial positions of said area.

48. Method or acoustic device according to any preceding claim, wherein the or each said member has its bounding edges coterminous with said area.

49. Method or acoustic device according to any preceding claim, wherein the or each said acoustic device has a frame applied about its edges so as to permit bending wave vibration thereat to a desired extent.

50. Method or acoustic device according to claim 49, wherein said frame is so applied with vibration-controlling material between said frame and said edges.

51. Method or acoustic device according any one of claims 1 to 47, wherein said area is defined within said transverse extent of said member by means adversely affecting passage of bending waves beyond said area.

52. Passive acoustic device according to, or obtainable by the method of, any preceding claim, adapted to use in any of reverberation, acoustic filtering and acoustic environmental voicing purposes.

53. Active acoustic device according to, or obtainable by the method of, any one of claims 1 to 51, further including transducer means coupled to said member, and adapted to use as either of a loudspeaker and a microphone.

54. Acoustic device according to claim 52 or claim 53,

wherein said member has an operative acoustic frequency range spanning more than 4KHz.

55. Acoustic device according to claim 52, 53 or 54, wherein said member has an operative acoustic frequency range that includes the coincidence frequency.

56. Acoustic device according to claim 52, 53 or 54, wherein said member has an operative acoustic frequency range that is wholly below the coincidence frequency.

57. Acoustic device according to any one of claims 52 to 56. wherein said member has a ratio of bending stiffness to mass per unit area consistent, for particular size of said member, with a lowest bending wave frequency lower than the acoustic operating frequency range of said device.

58. Acoustic device according to claim 57, wherein said lowest bending wave frequency is at least 20Hz.

59. Acoustic device according to claim 57 or claim 58, wherein said lowest bending wave frequency is at less than half, preferably about a third, of bottom of the acoustic operating frequency range.

60. Acoustic device according to claim 57, 58 or 59, wherein said member has bending stiffness between minima of about 0.1 to about 1,000 and maxima of about 4 to about 3,500 Newton-metres, and mass per unit area between minima of about 0.05 to about 1.5 and maxima of about 1 and about 4 kilograms/square metre, depending on size/application.

61. Acoustic device according to any one of claims 55 to 60, wherein said member is a stiff light-weight structure of laminated sandwich-type nature having a stiff cellular core and adhered skins to propagate bending waves and sustain said resonant modes at frequencies of interest.

62. Acoustic device according to claim 61, wherein said cellular core has shear modulus of at least about 10 mega-pascals and adhered skin Young's modulus of at least about 1 gigapascal.

63. Acoustic device according to claim 61, wherein said member, at least for sizes below about 0.1 square metre and lowest bending wave frequencies above about 100Hz, has a

bending stiffness that can be below about 10 Newtonmetres, core shear modulus that can be as low as about 10 megapascals or less and skins' Young's modulus in the range from about 0.5 to about 2.5 gigapascals.

64. Acoustic device according to claim 61, wherein said member, at least for sizes between about 0.1 and about 0.3 square metre and lowest bending wave frequencies as low as about 70Hz, has bending stiffness between about 5 and about 50 or more Newtonmetres, core shear modulus that is usually above 10 megapascals typically about 15 megapascals up to about 80 or more megapascals, and skins' Young's modulus of at least about 2 gigapascals up to about 70 or more gigapascals.

65. Acoustic device according to claim 61, wherein said member, at least for sizes between about 0.3 and about 1 square metres, has a lowest bending wave frequency that can be as low as about 50Hz, a bending stiffness usually above about 20 megapascals typically about 50 up to about 500 or more Newtonmetres, core shear modulus that is usually above about 10 typically about between about 20 and about 90 megapascals, and skins' Young's modulus of at least about 2 gigapascals feasibly up to at least about 70 gigapascals.

66. Acoustic device according to claim 61, wherein said member, at least for sizes over about 1 up to perhaps 5 square metres or more and lowest bending wave frequency that can be as low as about 25 to 70Hz, has bending stiffness above about 25 Newtonmetres, core shear modulus usually over 30 megapascals, and skins' Young's modulus of at least about 20 gigapascals ranging up to at least about 1,000 gigapascals.

67. Acoustic device according to any one of claims 61 to 66, wherein said core has cells capable of contributing useful additional volume-related high frequency non-bending wave resonances.

68. Acoustic device according to any one of claims 61 to 67, wherein said core has structure capable of contributing useful additional high frequency compression/recovery non-

bending wave resonances.

69. Acoustic device according to any one of claims 61 to 67, wherein said core has cells cooperating with said skins to afford useful tiny drum-like (cell-cap) additional high frequency non-bending wave resonances.

70. Acoustic device according to any one of claims 53 to 69, wherein compliance of mounting said transducer means to said member core affords useful additional low frequency non-bending wave resonances.

71. Acoustic device according to any one of claims 52 to 70, wherein compliance of supporting said member affords useful additional low frequency non-bending wave resonances.

72. Acoustic device according to any one of claims 53 to 71, wherein said transducer means has at least a movable bending wave operative part thereof mechanically coupled to said member predominantly resistively.

73. Acoustic device according to any one of claims 53 to 72, wherein said transducer means is of piezoelectric type.

74. Acoustic device according to any one of claims 53 to 72, wherein said transducer means is of electromagnetic coil-and-magnet type.

75. Acoustic device according to claim 74, wherein said electromagnetic transducer means is of moving-coil type.

76. Acoustic device according to any one of claims 53 to 75, wherein said transducer means is surface-mounted to said member.

77. Acoustic device according to any one of claims 53 to 75, wherein said transducer means has at least a movable bending wave operative part mounted in a recess into the thickness of said member.

78. Acoustic device according to any one of claims 53 to 77, wherein said transducer means has its movable bending wave operative part mounted to occupy less than 0.1% of surface area of said member.

79. Acoustic device according to any one of claims 53 to 78, wherein said transducer means has its movable bending

wave operative part of mass about 1 to 2 times that of portion of said member covered or removed to accommodate said part.

80. Acoustic device according to any one of claims 53 to 79, wherein said transducer means is wholly carried by said member.

81. Acoustic device according to any one of claims 53 to 80, wherein said member has a substantially rectangular acoustically operative said area, and said transducer means is located at a position substantially corresponding to 3/7 and/or 4/9 and/or 5/13 of lengths of sides of said member used as coordinates from a corner of said area or member.

82. Acoustic device according to any one of claims 53 to 80, wherein said member has a substantially true elliptical acoustically operative said area, and said transducer means is located at a position substantially corresponding, as coordinates from centre of said area or member, to 0.43 and 0.20 of its half-major and half-minor axes having relative length ratio of substantially 1:1.182.

83. Acoustic device according to any one of claims 53 to 80, wherein said member has a substantially super-elliptical acoustically operative said area, and said transducer means is located at at a position inside outer edge of said area or member by about 15% of a line to its centre.

84. Method according to any preceding method claim, wherein said analysis extends to assessing vibrational energy content of parts or subareas of said area for contributions from predetermined said natural resonant modes, the method further comprising determining at least one location within said area for bending wave transducer means by first finding at least one region of said area having said contributions from high or highest numbers of said predetermined resonant modes.

85. Method according to any preceding method claim, wherein said analysis extends to assessing vibrational energy content of parts or subareas of said area for contributions from said predetermined natural resonant modes, the method

further comprising determining two or more locations within said area for bending wave transducer means by first finding regions collectively having contributions from most up to all of said predetermined resonant modes.

86. Method of making an acoustic device having a member extending transversely of its thickness in an area of prescribed configuration and capable of sustaining bending waves over said area, the method comprising determining location in said area for bending wave transducer means by analysis of distribution of vibrational energy from predetermined resonant modes of natural bending wave vibration of said member over said area, and identifying at least one region in said area at which high or highest numbers of said predetermined resonant modes contribute significant vibrational energy.

87. Method of making an acoustic device having a member extending transversely of its thickness in an area of prescribed configuration and capable of sustaining bending waves over said area, the method comprising determining location in said area for bending wave transducer means by analysis of distribution of vibrational energy from predetermined resonant modes of natural bending wave vibration of said member over said area, and identifying two or more regions in said area that in combination have significant vibrational energy contributions from most or all of said predetermined resonant modes.

88. Method according to any one of claims 84 to 87, wherein said analysis additionally or alternatively identifies two or more regions of said area that have substantially complementary vibrational energy contributions from said predetermined resonant modes.

89. Method according to any one of claims 84 to 88, comprising the step of mounting transducer means to couple with at least those of said resonant modes contributing to a said region.

90. Acoustic device comprising a member extending transversely of its thickness and capable of sustaining areal

bending waves over its area, wherein the member has at least one transducer means coupled directly thereto at at least one location that is asymmetric in geometrical configuration of said member and at least about 10% to 15% inside said area along a notional line to its centre.

91. Acoustic device according to claim 90, wherein the or each said location for said transducer means is off said line, including any centre line(s) or other axes of said area by at least 7%.

92. Acoustic device according to claim 90 or claim 91, wherein the or each said location for said transducer means is where there is coupling to substantial complexity of vibrational cont-ributions from plural resonant modes of natural bending wave vibration of said member.

93. Acoustic device according to claim 92, wherein said geometrical configuration of said member is proportioned taking into account any directional differences of bending stiffness for distribution of vibrational content due to bending wave action at its natural resonant modes that is beneficial to acoustic performance of the device.

94. Acoustic device according to claim 93, comprising a microphone, wherein plural said transducer means have their said locations each as far as practicably different as to relative values of coordinates of its position in said area.

95. A panel-form loudspeaker (81) comprising a resonant distributed mode acoustic radiator (2), and drive means (9) mounted to the radiator to excite distributed mode resonance in the radiator, characterised by a baffle (6,8) surrounding and supporting the radiator.

96. A panel-form loudspeaker comprising a resonant distributed mode acoustic radiator having a periphery, a transducer mounted to the radiator to excite distributed mode resonance in the radiator, and a frame supporting the radiator, the transducer being coupled between the radiator and the frame to vibrate the panel to cause it to resonate to produce an acoustic output, characterised in that the

frame supports the radiator round its periphery and by resilient suspension means coupled between the frame and the radiator periphery.

97. A loudspeaker comprising an enclosure, an acoustic radiator in the enclosure, a compliant suspension mounting the radiator in the enclosure for pistonic movement relative thereto, and transducer means for driving the radiator pistonically, characterised in that the radiator is a panel-form distributed mode acoustic radiator, by a first transducer mounted wholly and exclusively on the radiator to vibrate the radiator to cause it to resonate, and by means for varying the air pressure in the enclosure to cause the radiator to move pistonically.

98. An inertial vibration transducer characterised by an assembly comprising a motor coil having a coil rigidly fixed to a tubular member, by a magnet assembly disposed concentrically within the motor coil, and by resilient means supporting the magnet assembly for axial movement relative to the motor coil, the motor coil member being adapted to be rigidly mounted to a distributed mode radiator.

99. A loudspeaker comprising an inertial transducer as claimed in any preceding claim.

100. An inertial vibration transducer characterised by a plate-like piezo-electric bender and means adapted to mount the bender on a member to be vibrated, the arrangement being such that a substantial part of the bender is spaced from the member for movement relative thereto.

101. A loudspeaker having a distributed mode acoustic radiator, characterised by a transducer as claimed in any preceding claim coupled to vibrate the radiator to cause it to resonate.

102. A vibration transducer to vibrate a member having a face, characterised by a motor coil assembly having a coil rigidly fixed to a tubular member, the motor coil assembly being adapted to be fixed to the said face of the member, and by a magnet assembly comprising opposed disc-like pole

pieces, the periphery of one of which pole pieces is arranged to be disposed with and adjacent to the motor coil assembly, and the periphery of the other of which pole pieces is formed with a surrounding flange adapted to surround and to be disposed adjacent to the motor coil assembly, and characterised in that the magnet assembly is adapted to be secured at its centre to the said member to be vibrated.

103. A loudspeaker characterised by a distributed mode acoustic radiator and by a transducer as claimed in any preceding claim coupled to vibrate the radiator to cause it to resonate.

104. A panel-form loudspeaker having a distributed mode acoustic radiator and a first transducer coupled to the radiator to excite distributed mode resonance in the radiator, characterised by a second transducer coupled to vibrate the radiator.

105. A panel-form loudspeaker having a distributed mode acoustic radiator and a transducer coupled to vibrate the radiator to cause it to resonate, characterised by a second transducer coupled to the radiator to produce a signal in response to resonance of the radiator due to incident acoustic energy.

106. A panel-form microphone characterised by a distributed mode acoustic member and a transducer coupled wholly and exclusively to the member to produce a signal in response to resonance of the member due to incident acoustic energy.

107. A suspended ceiling tile incorporating a loudspeaker, characterised in that the tile comprises a distributed mode acoustic radiator, and by a transducer mounted wholly and exclusively on the radiator to vibrate the radiator to cause it to resonate.

108. A visual display unit comprising a display screen and a housing in which the display screen is mounted, characterised in that the housing carries a loudspeaker comprising a distributed mode acoustic radiator and transducer means mounted wholly and exclusively on the

radiator to vibrate the radiator to cause it to resonate.

109. A lap-top computer comprising a keyboard and a display screen, characterised in that the display screen is, or forms part of, a distributed mode acoustic radiator loudspeaker having a transducer mounted wholly and exclusively thereon to vibrate the radiator to cause it to resonate to produce an acoustic output.

110. A portable compact-disc player, characterised by an opposed pair of panel-form loudspeakers attached to the player, and in that each loudspeaker comprises a distributed mode acoustic radiator having a transducer mounted wholly and exclusively thereon to vibrate the radiator to cause it to resonate.

111. A vehicle having a passenger compartment and a loudspeaker in the passenger compartment, characterised in that the loudspeaker comprises distributed mode acoustic radiator and a transducer mounted wholly and exclusively on the radiator to vibrate the radiator to cause it to resonate.

112. A vehicle component comprising a loudspeaker, characterised by a distributed mode acoustic radiator and a vibration transducer mounted on the radiator to vibrate the radiator to cause it to resonate.

113. An electronic musical instrument having a keyboard, characterised by a loudspeaker comprising a distributed mode acoustic radiator and a transducer mounted wholly and exclusively on the radiator to vibrate the radiator to cause it to resonate.

114. A vending machine of the kind comprising a store of articles or product to be dispensed, user operated means for selecting the article or product to be dispensed, means, e.g. a coin-freed mechanism, authorising dispensing, and a dispensing outlet, characterised by a loudspeaker comprising a distributed mode acoustic radiator and a transducer mounted wholly and exclusively on the radiator to vibrate the radiator to cause it to resonate.

115. Visual display apparatus comprising a notice or the

like board, characterised in that the notice or the like board is a distributed mode acoustic radiator having a transducer mounted wholly and exclusively thereon to vibrate the radiator to cause it to resonate.

116. Packaging comprising a board component, characterised in that the board is a distributed mode acoustic radiator having a transducer mounted wholly and exclusively on the radiator to vibrate the radiator to cause it to resonate.

117. A greetings or the like card, characterised by a board forming at least part of the card and in that the board is a distributed mode acoustic radiator having a transducer mounted wholly and exclusively on the radiator to vibrate the radiator to cause it to resonate.

118. A display screen comprising a panel having a light reflective or light emitting surface, characterised in that the screen is a distributed mode acoustic radiator loudspeaker having a transducer mounted wholly and exclusively thereon to vibrate the radiator to cause it to resonate to provide an acoustic output.

119. Audio visual apparatus characterised by a display screen as claimed in claim 118.

120. A display screen comprising a panel having a light reflective or light emitting surface, characterised in that the screen is a distributed mode acoustic radiator loudspeaker having a transducer mounted wholly and exclusively thereon to vibrate the radiator to cause it to resonate to provide an acoustic output.

121. Audio visual apparatus characterised by a display screen as claimed in claim 120.

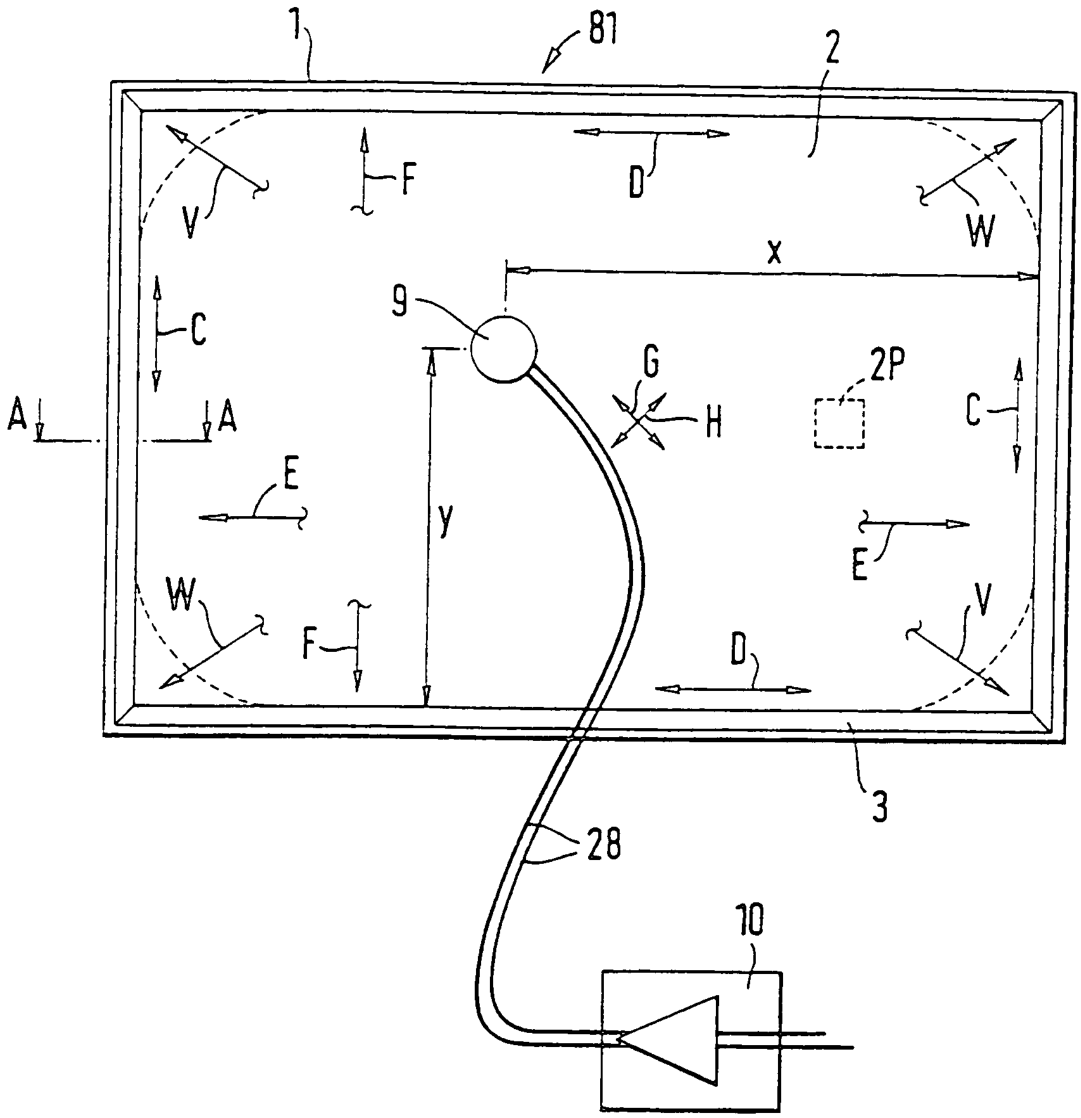


Fig. 1

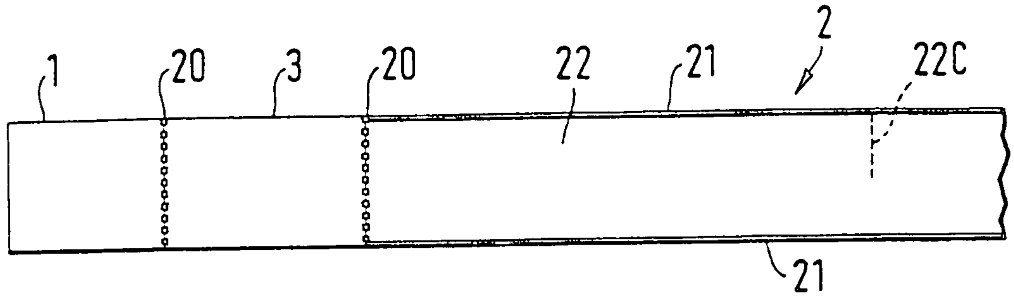


Fig. 2a

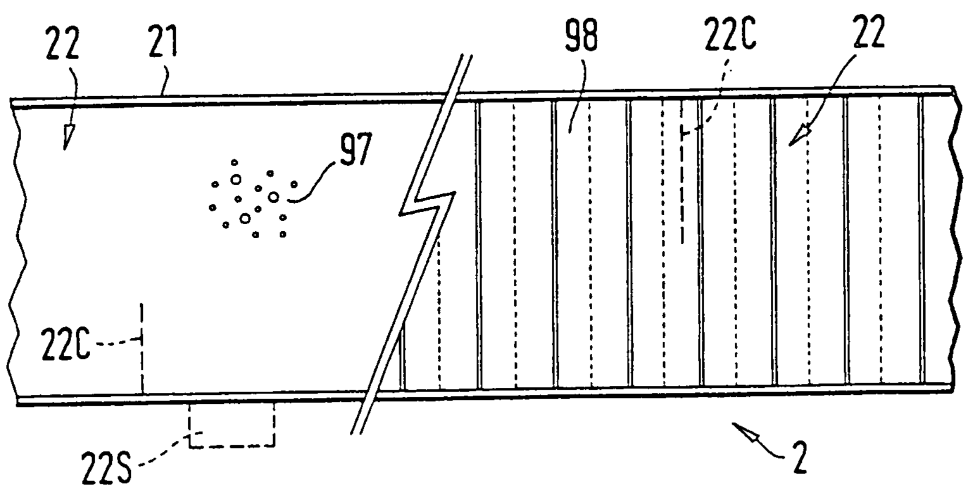


Fig. 2b

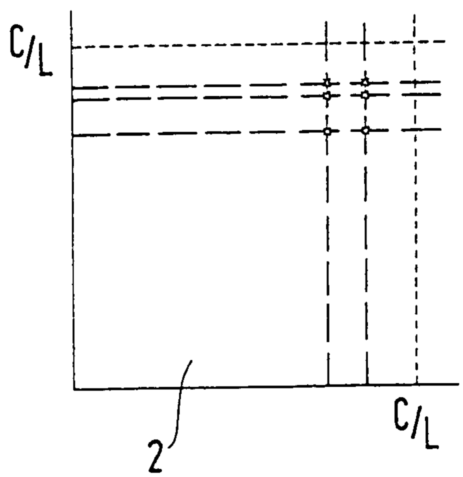


Fig.3a

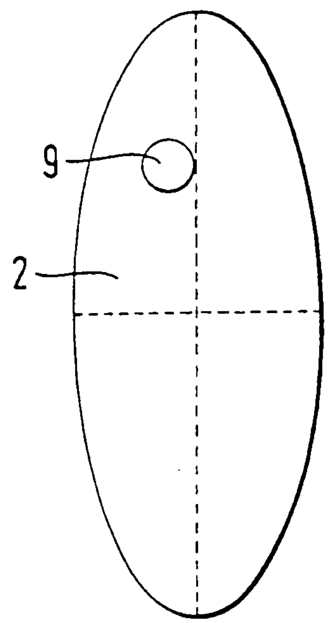


Fig.3b

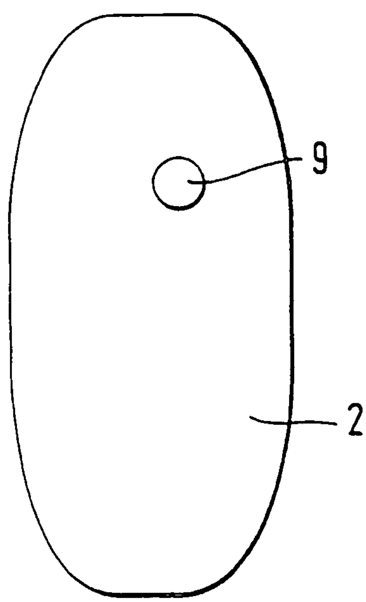


Fig.3c

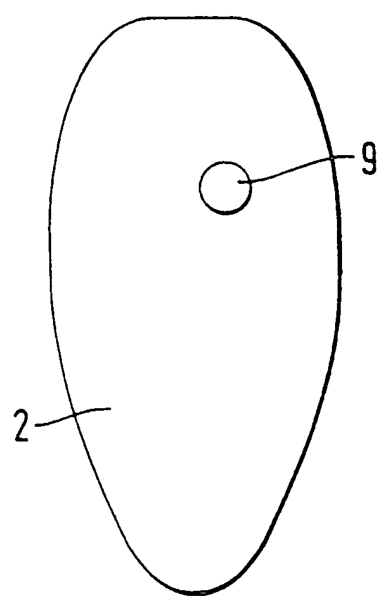


Fig.3d

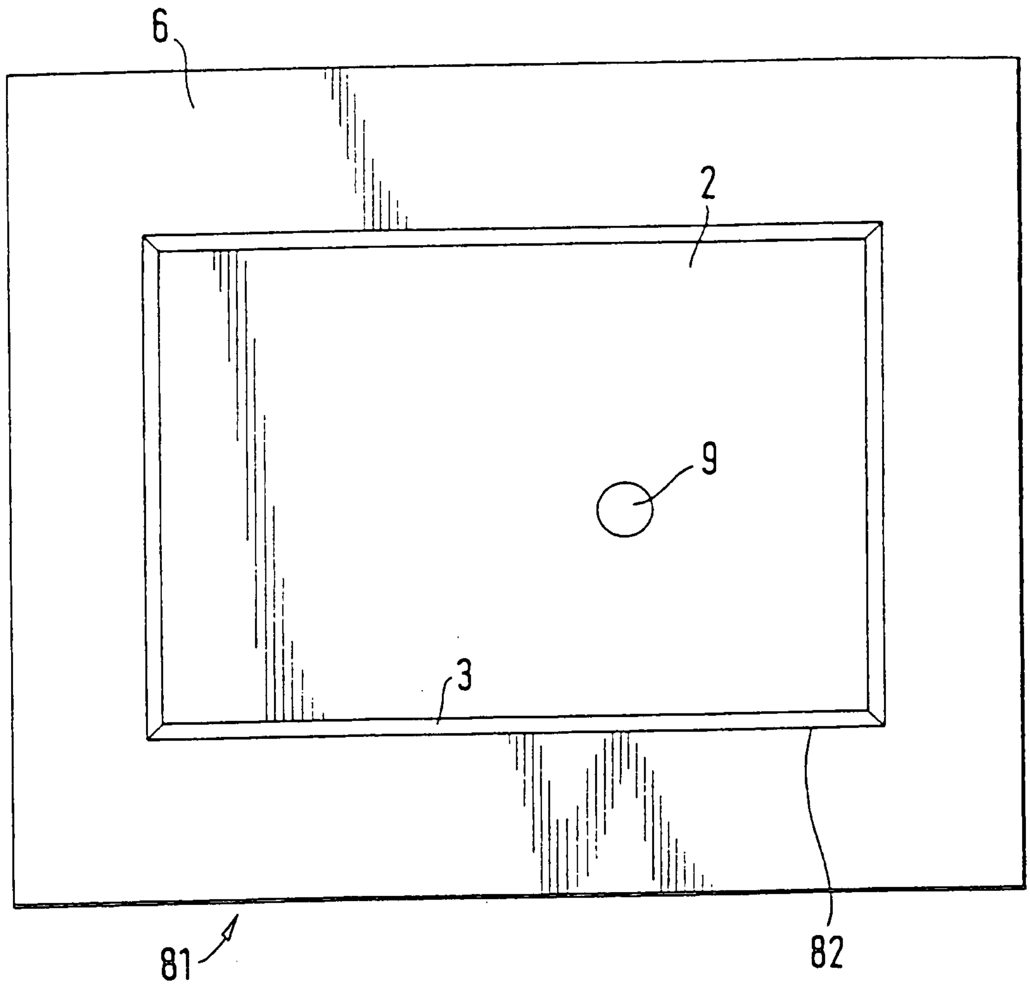


Fig.4

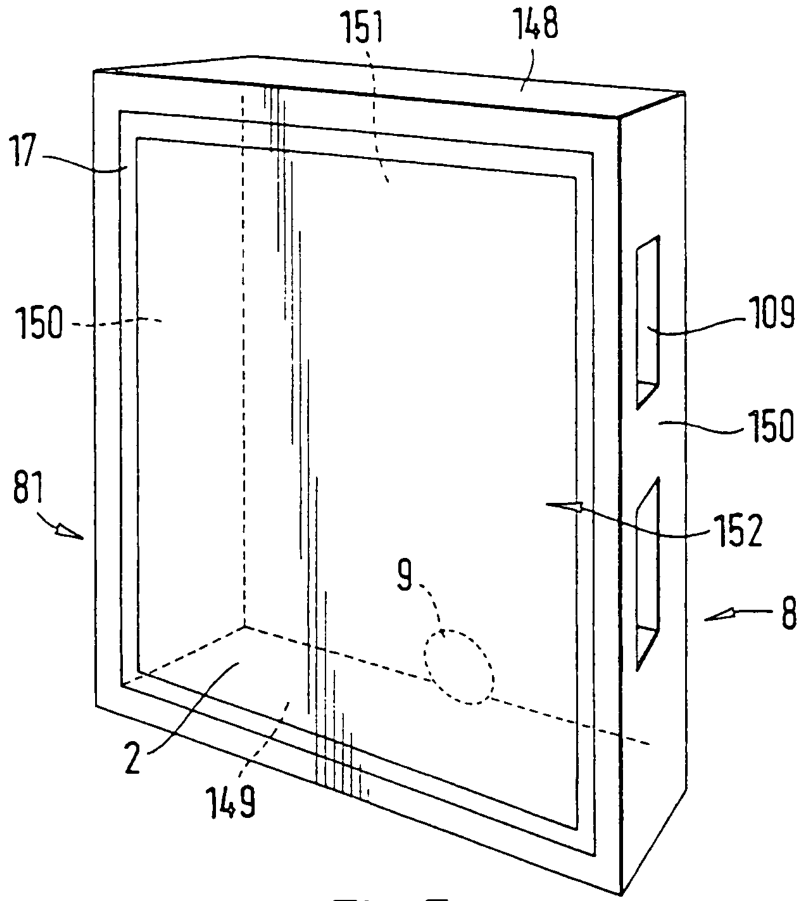


Fig.5a

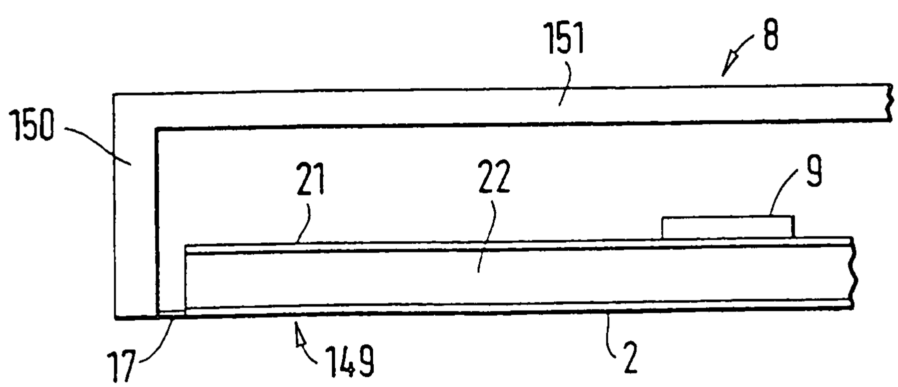


Fig.5b

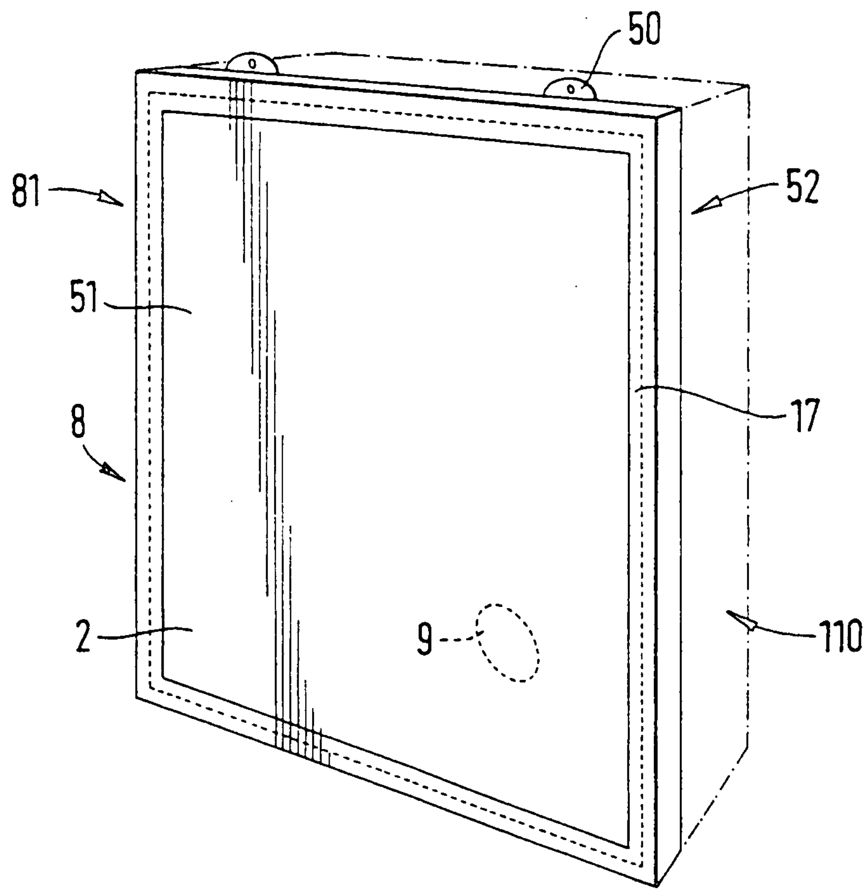


Fig.6a

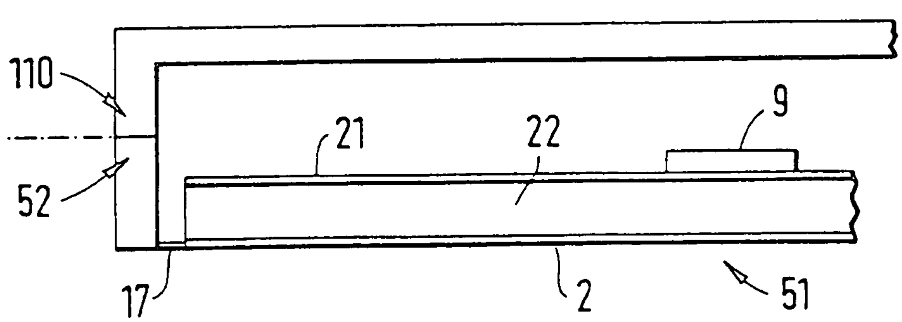


Fig.6b

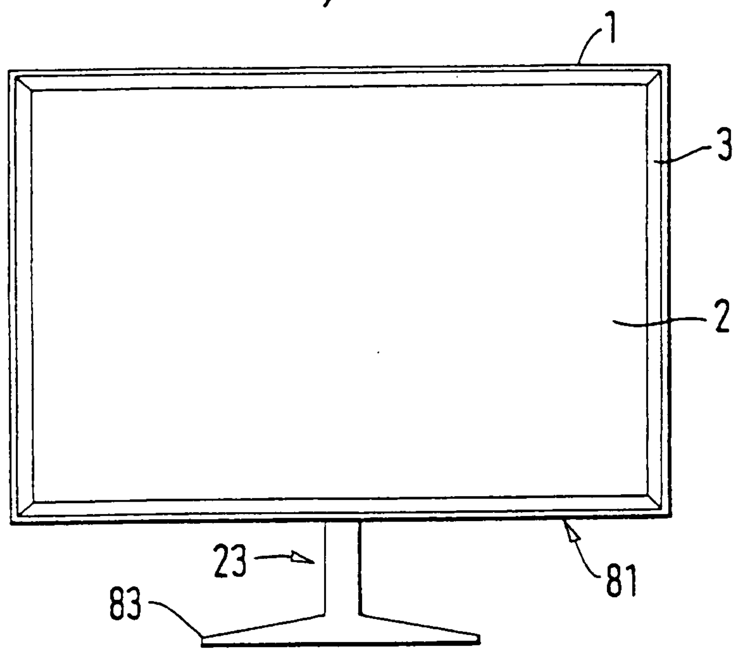


Fig. 7a

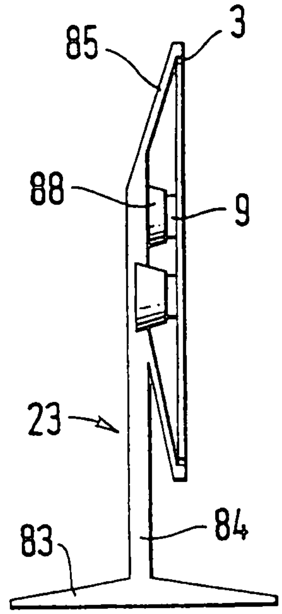


Fig. 7b

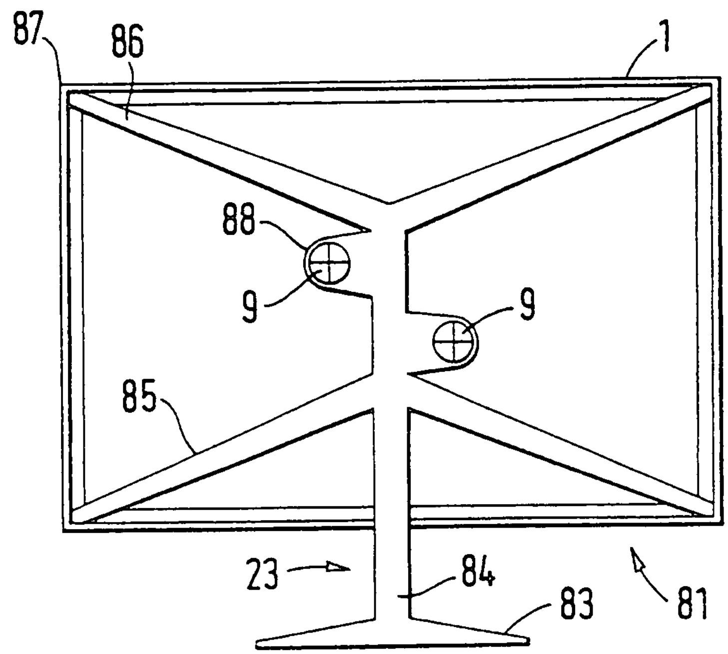


Fig. 7c

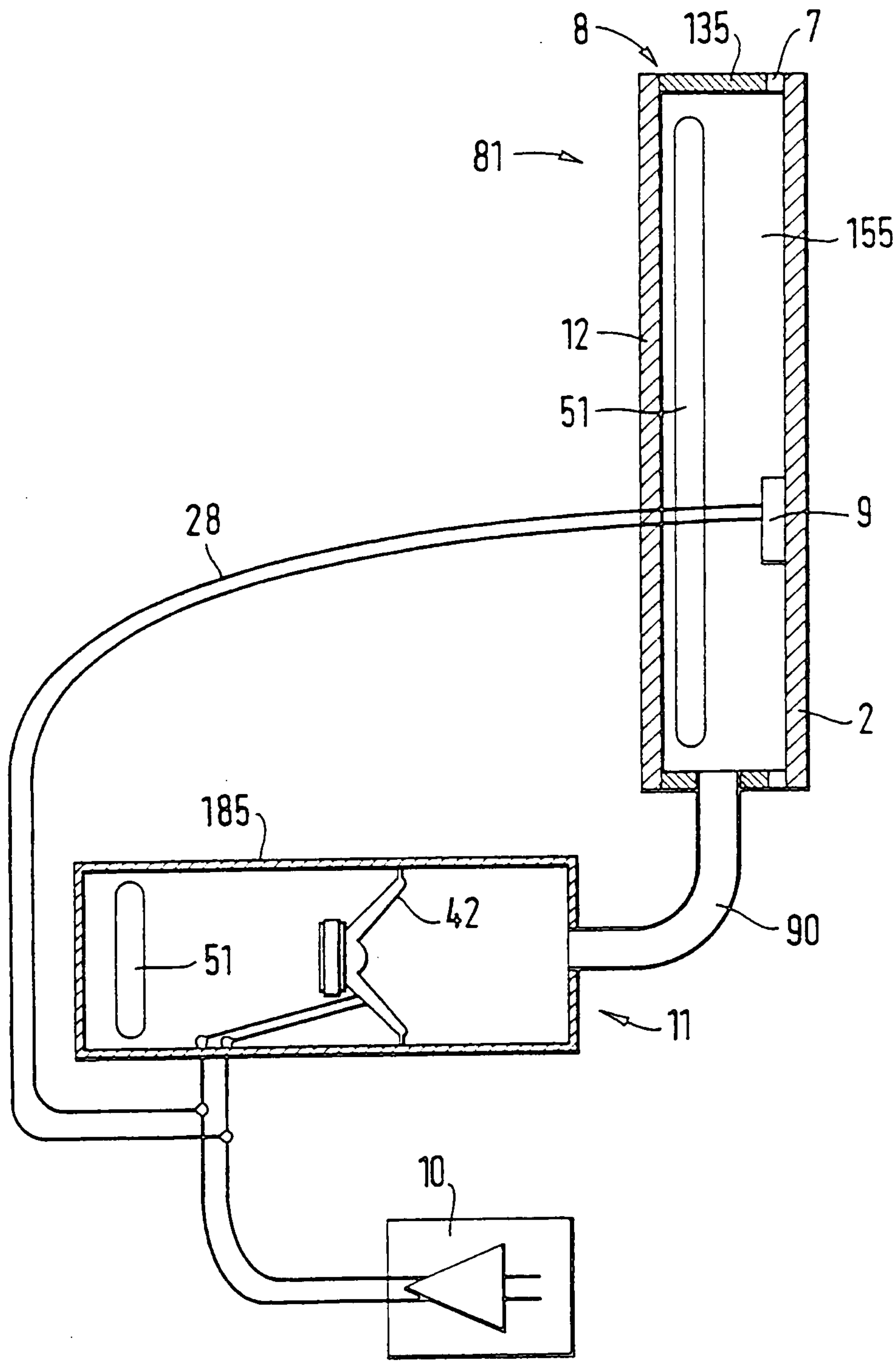


Fig. 8

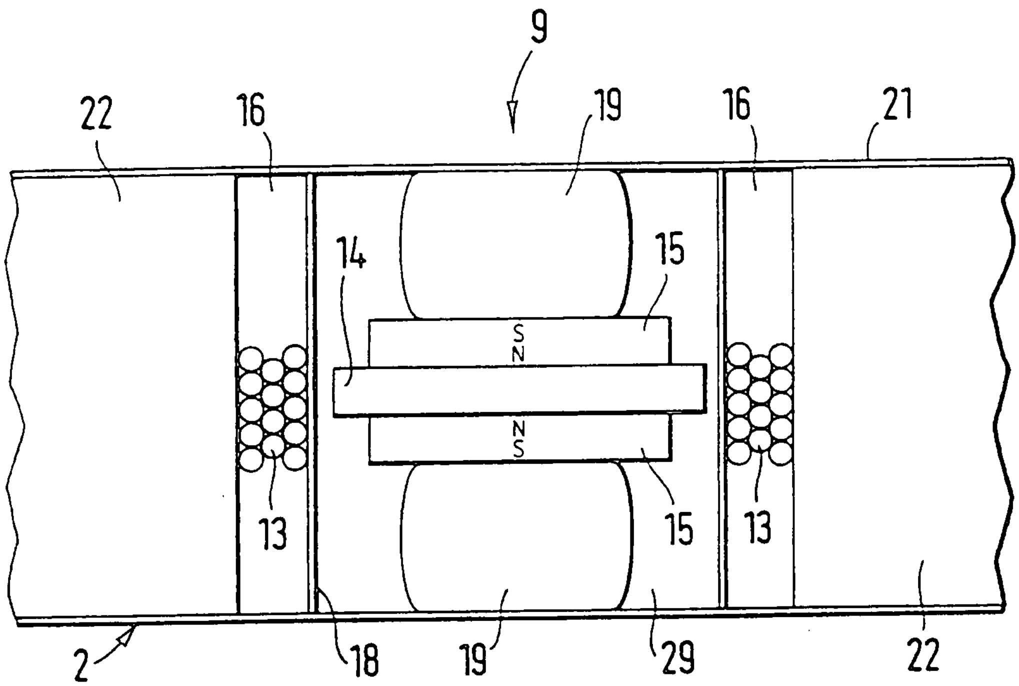


Fig. 9

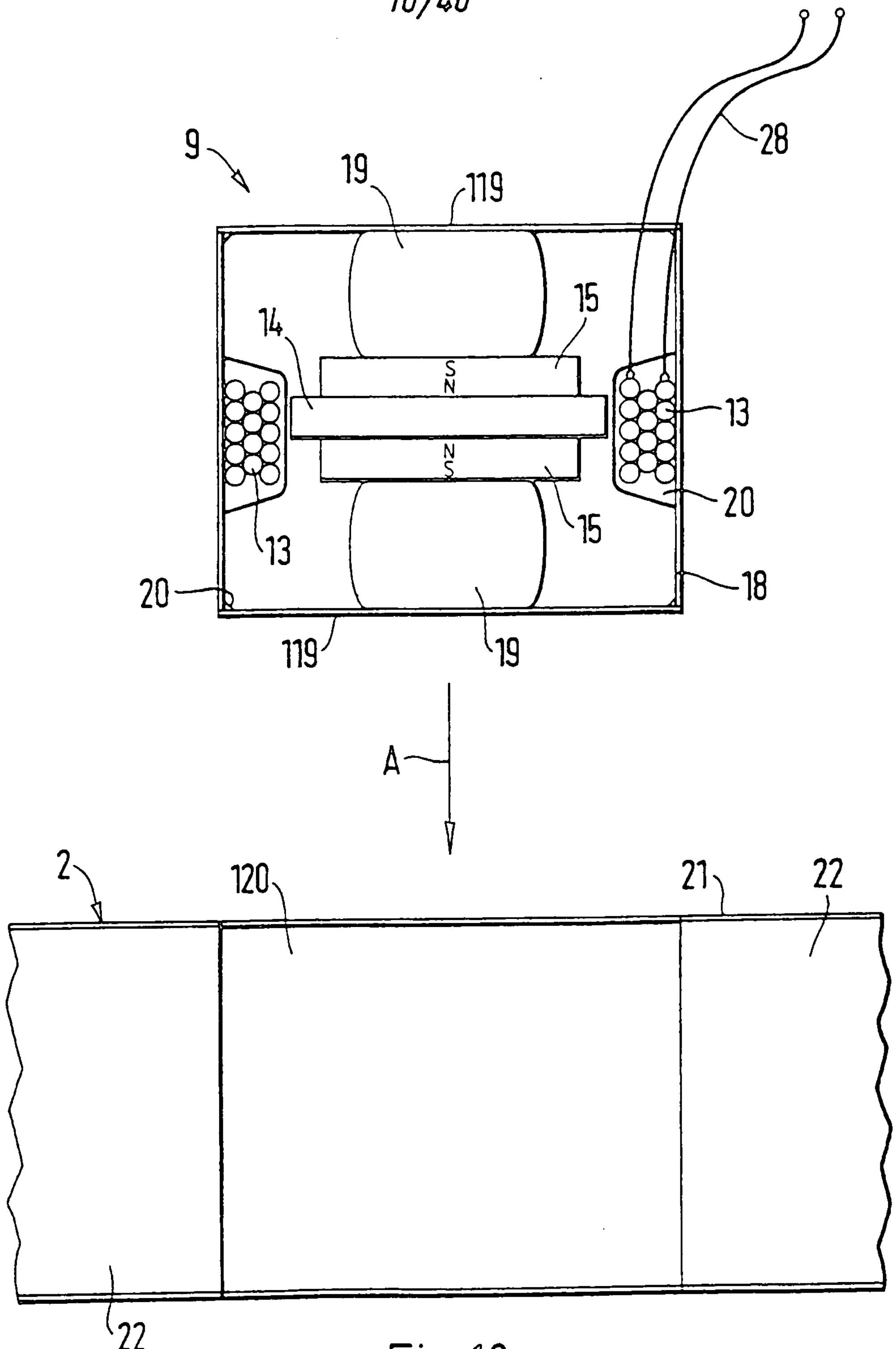


Fig.10

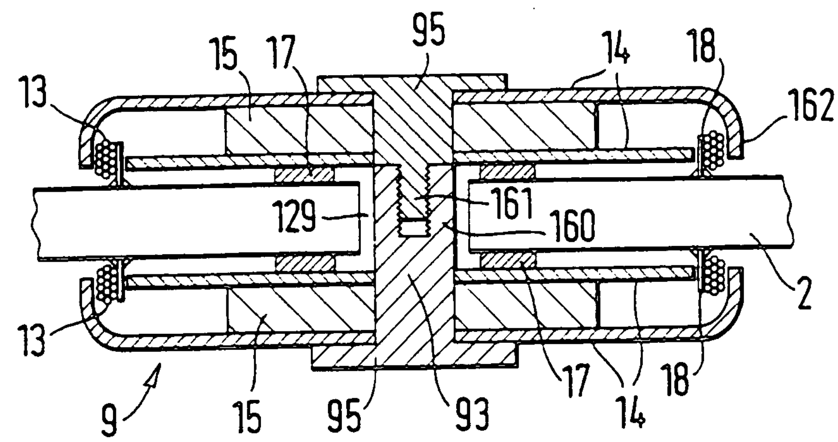


Fig.11a

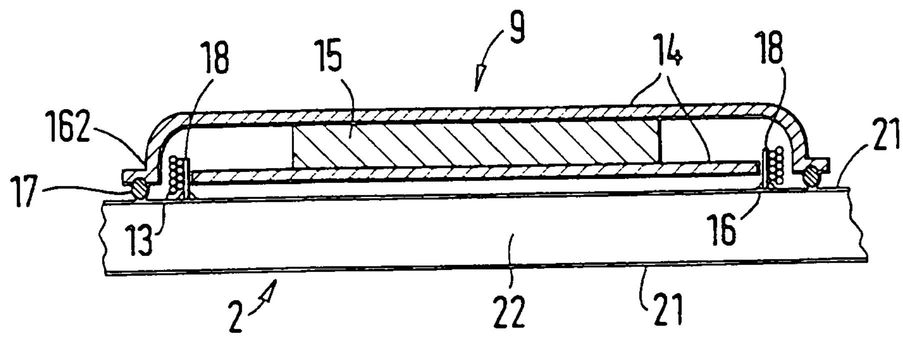


Fig.11b

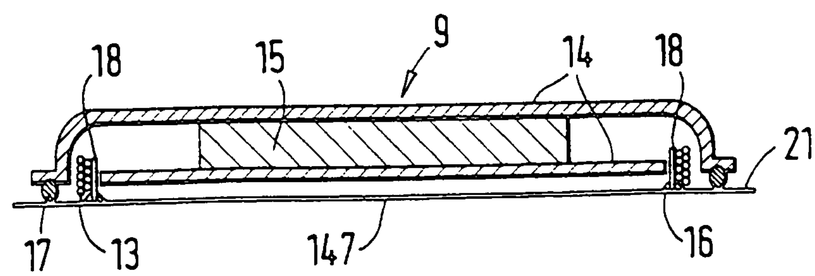


Fig.11c

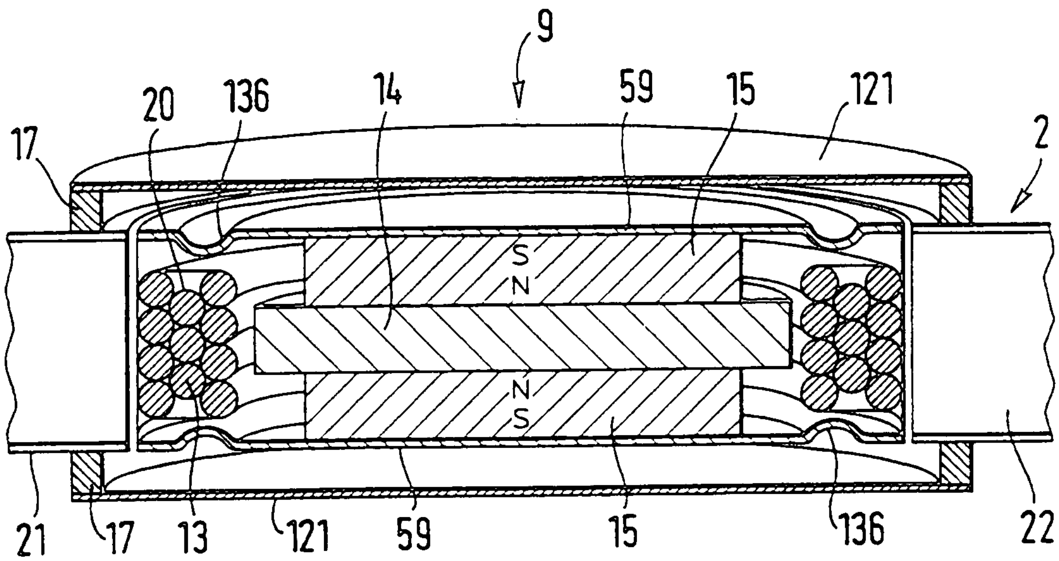


Fig. 12

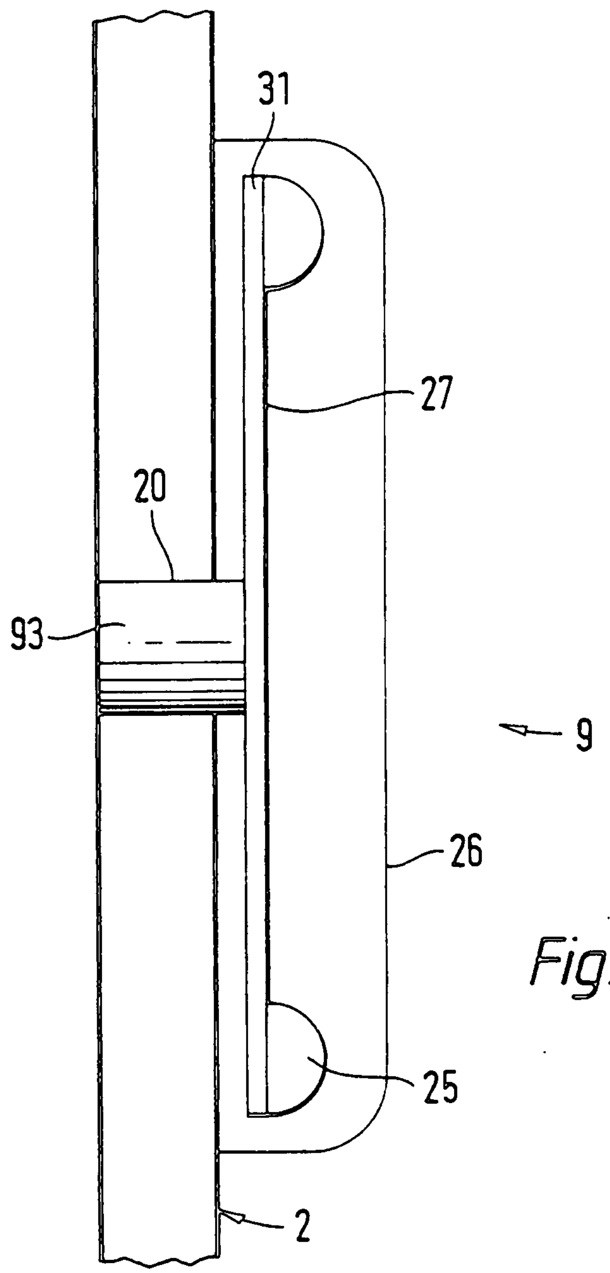


Fig.13

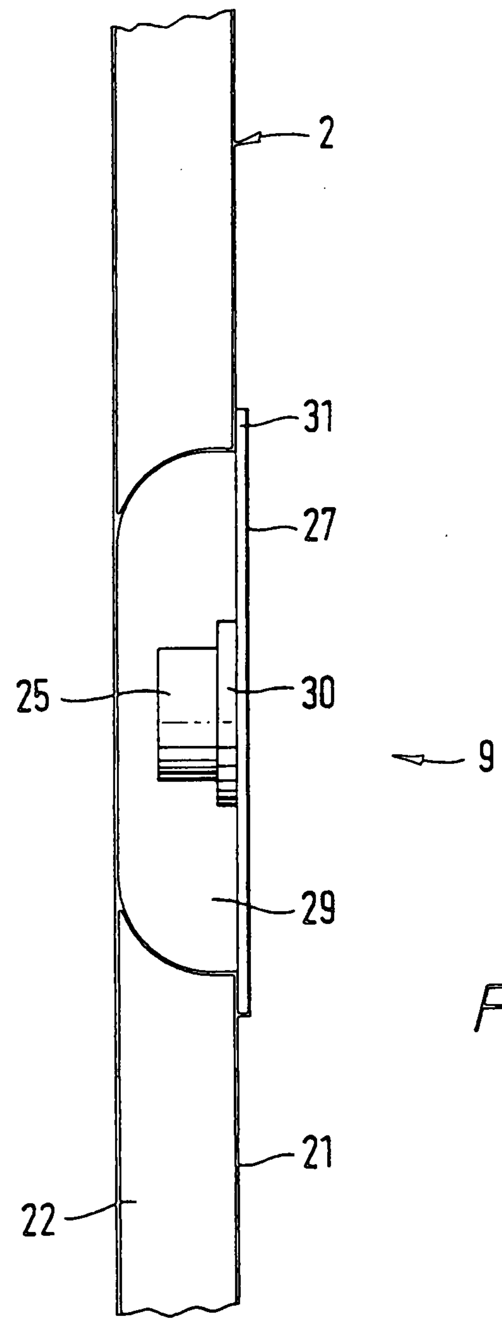


Fig. 14

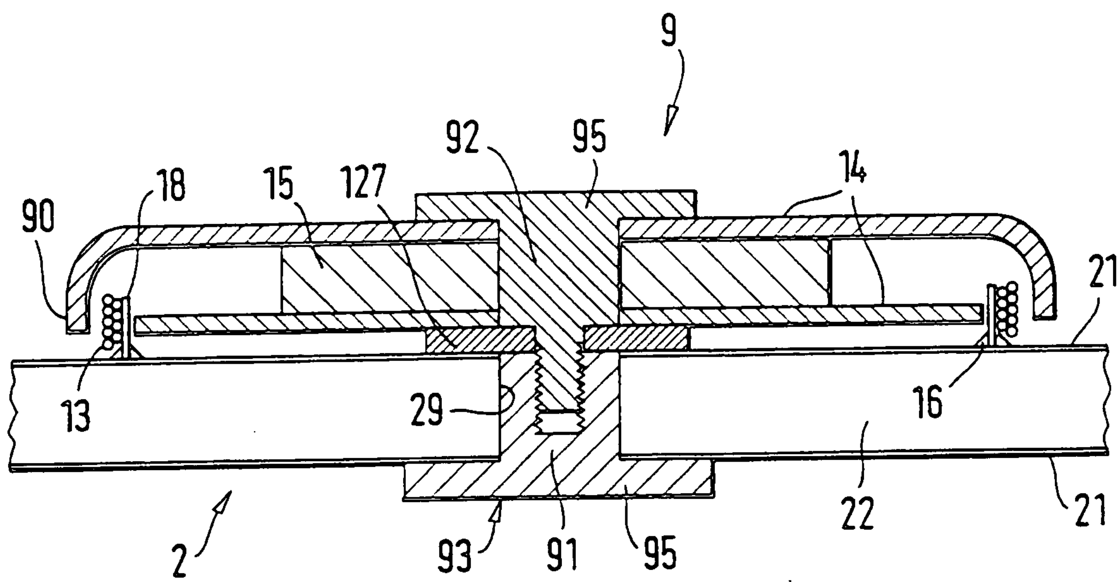


Fig. 16

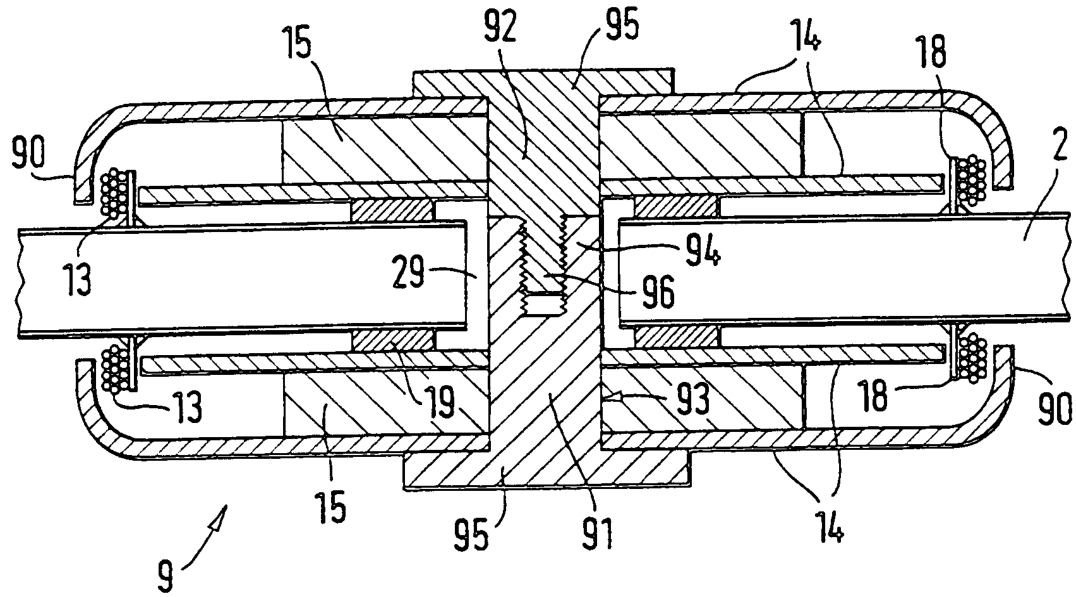


Fig. 17

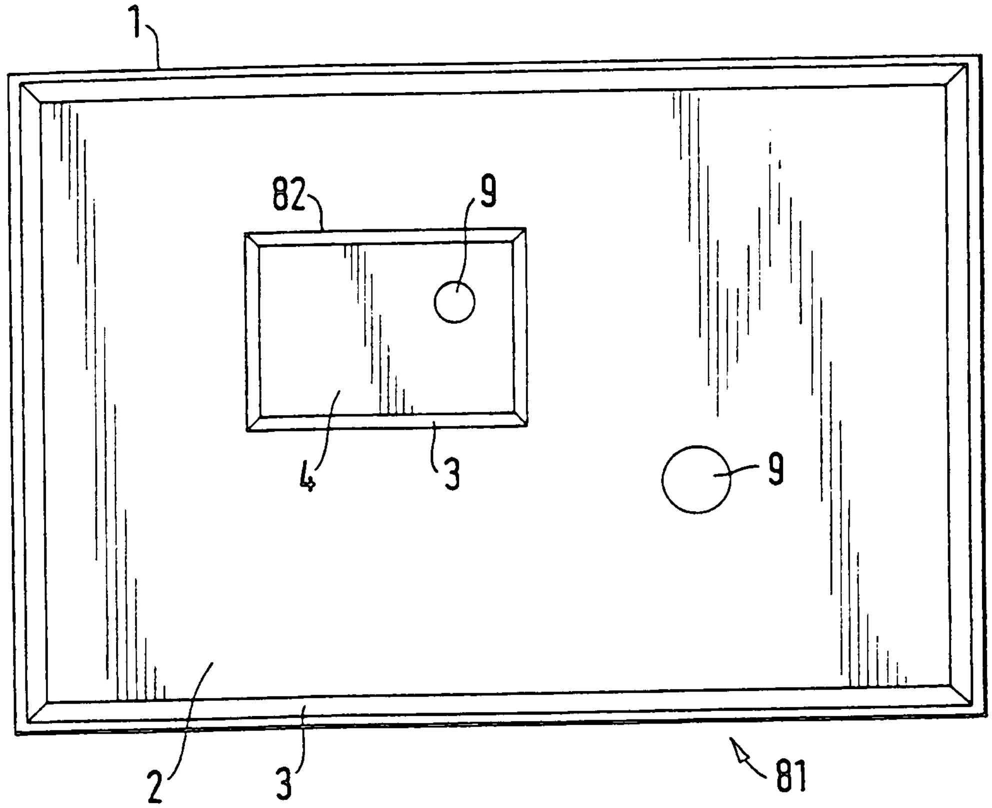


Fig.18

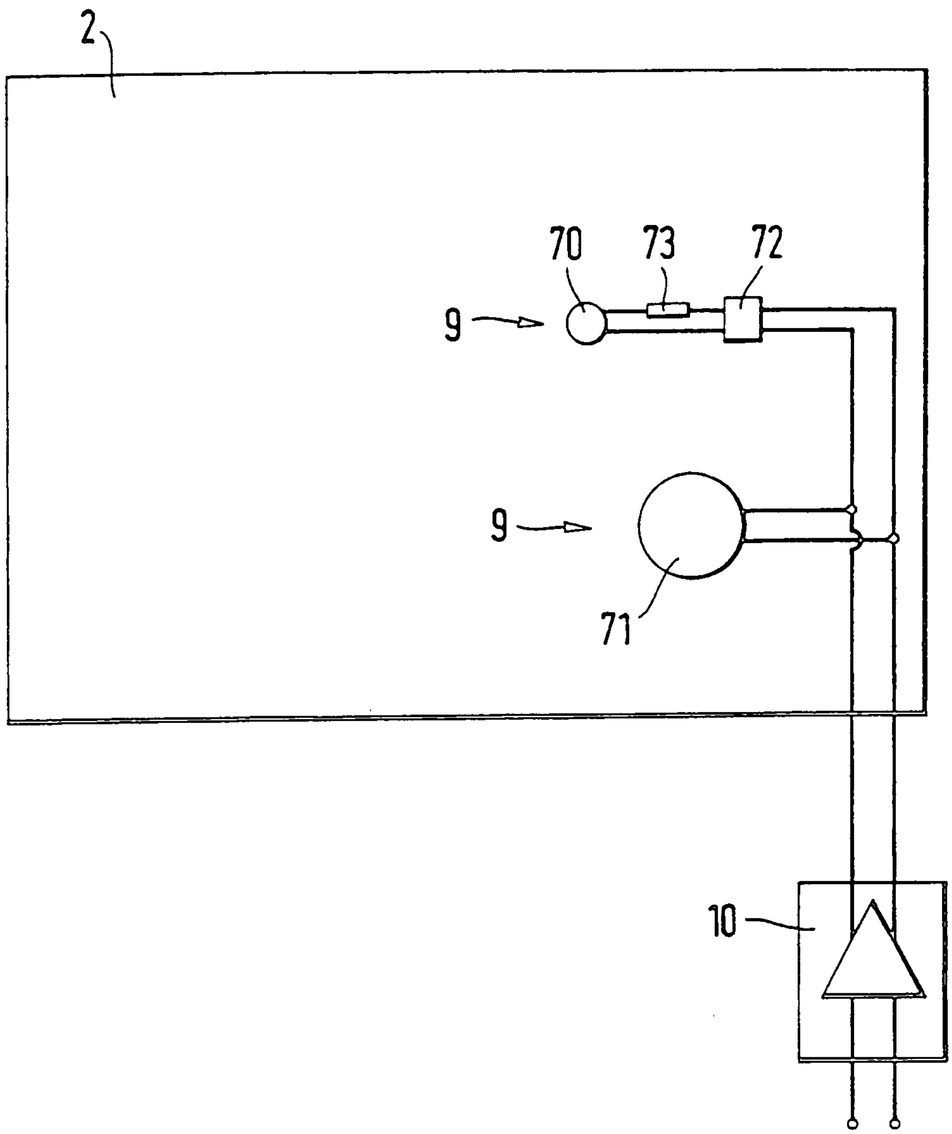


Fig.19

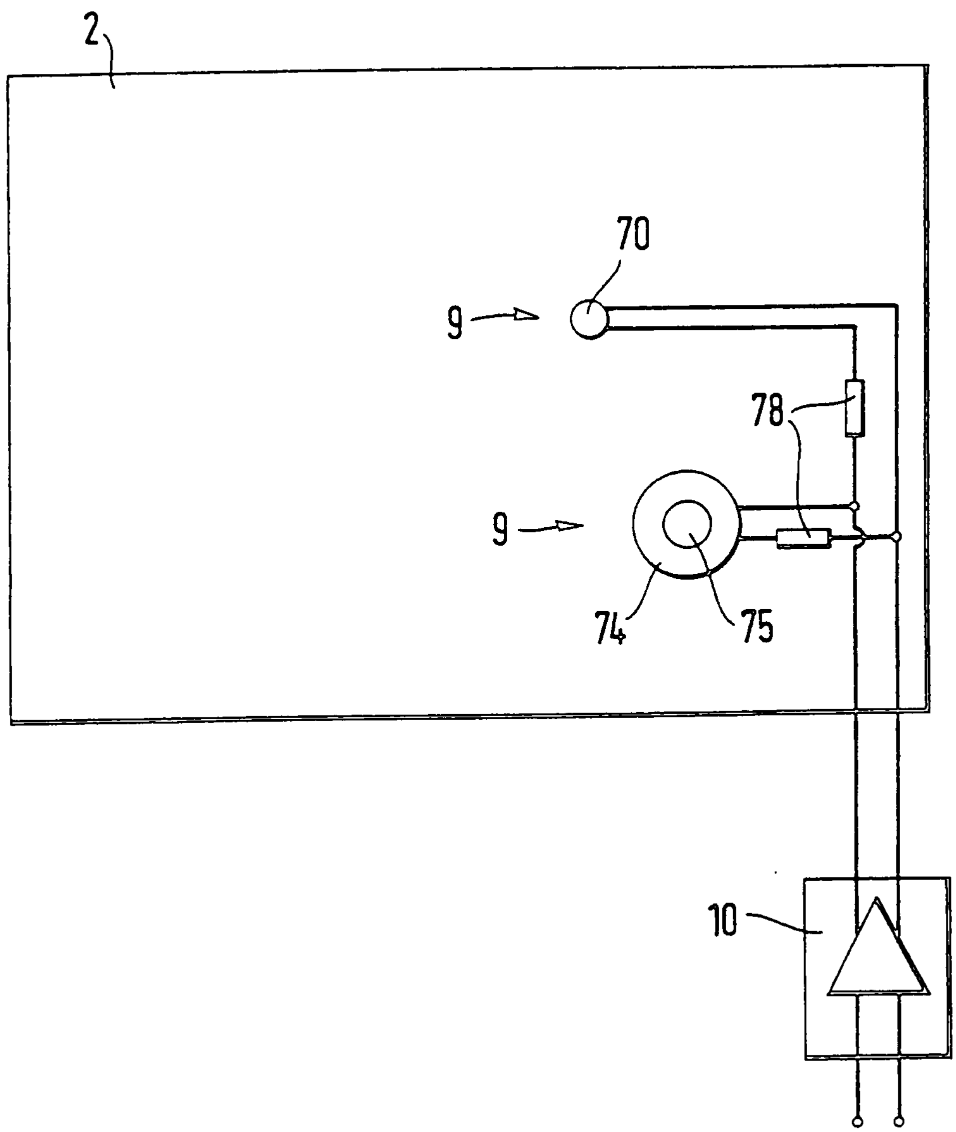


Fig. 20

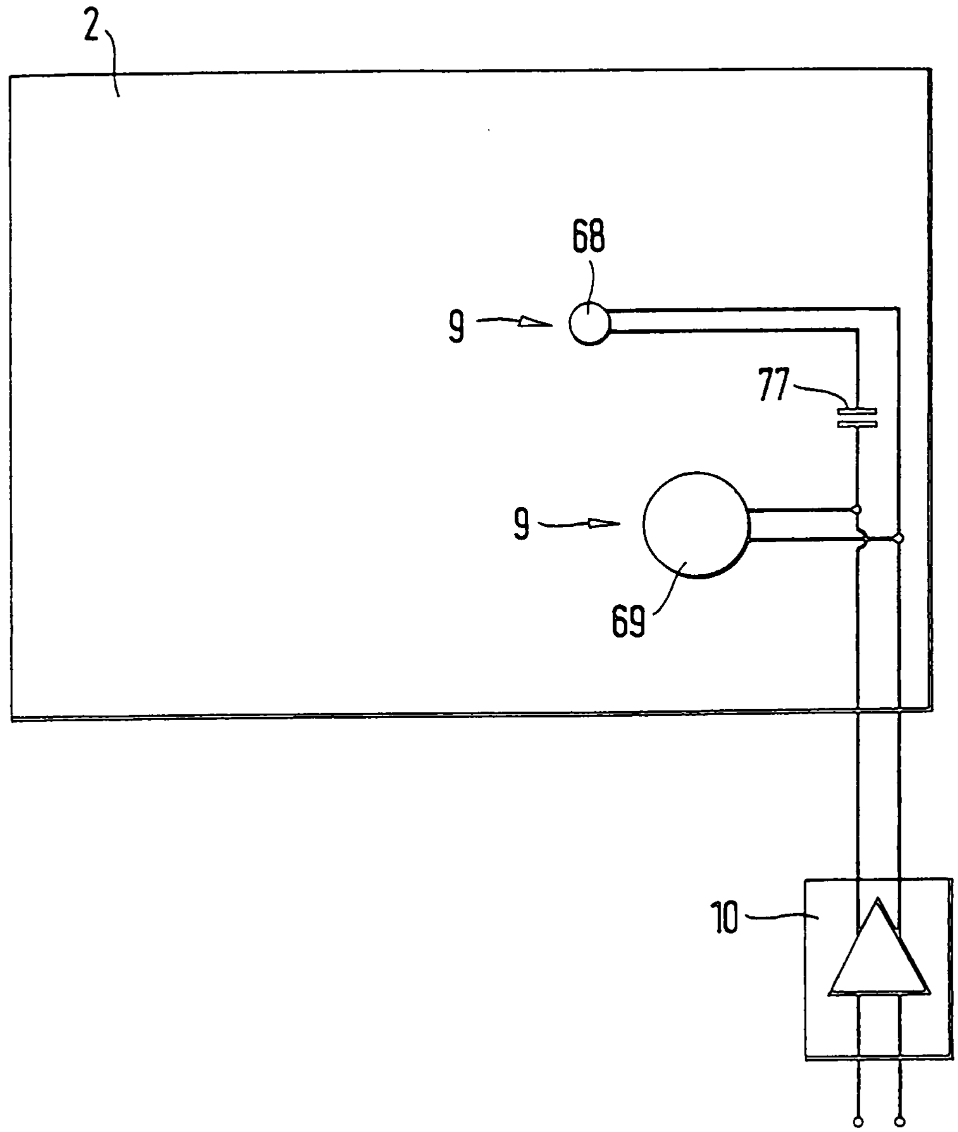


Fig.21

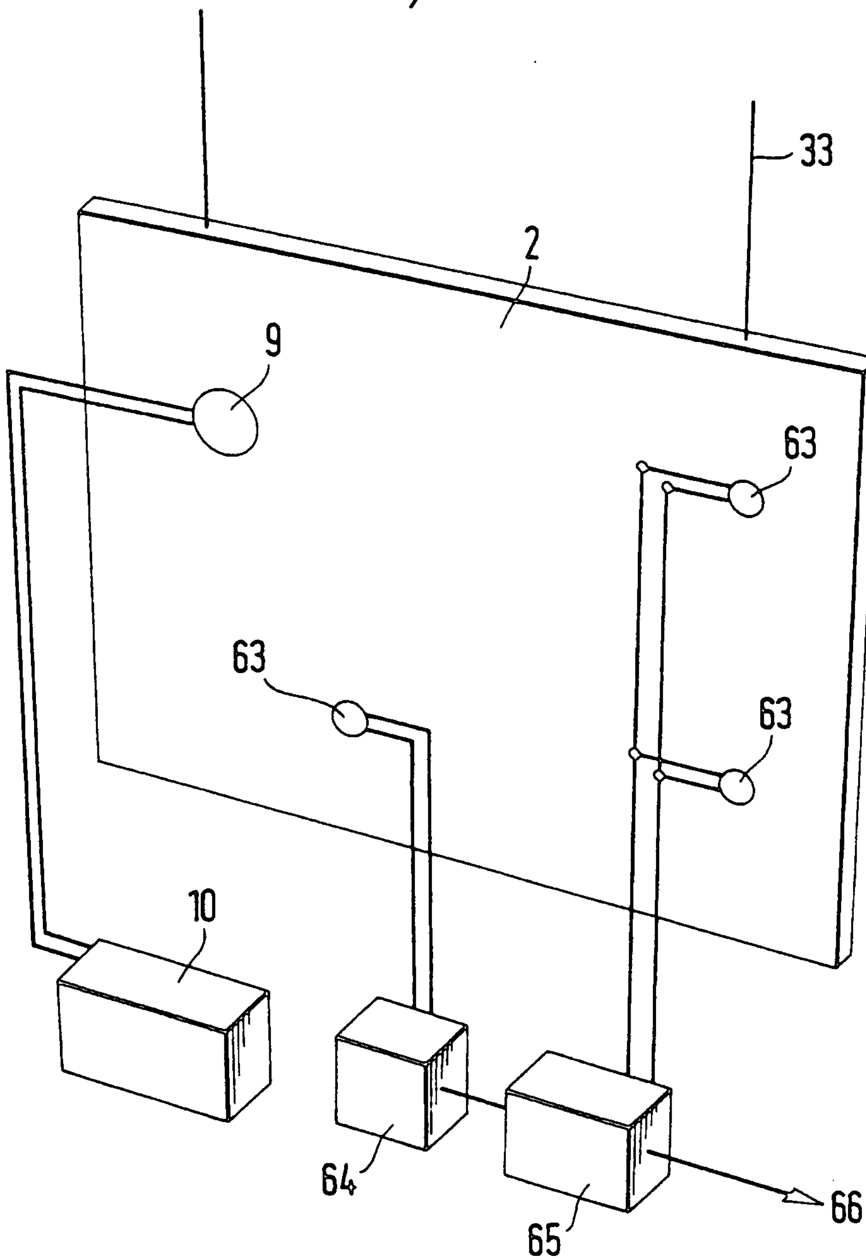


Fig. 22

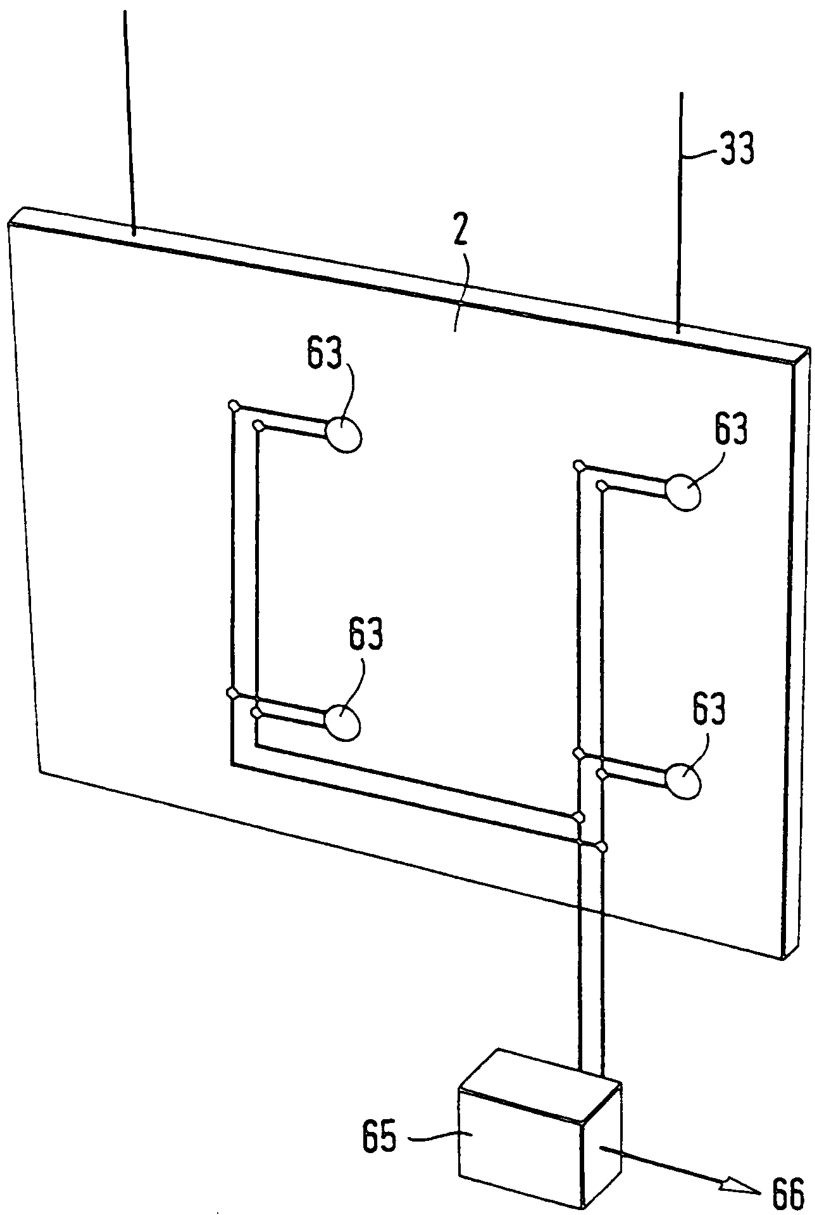


Fig. 23

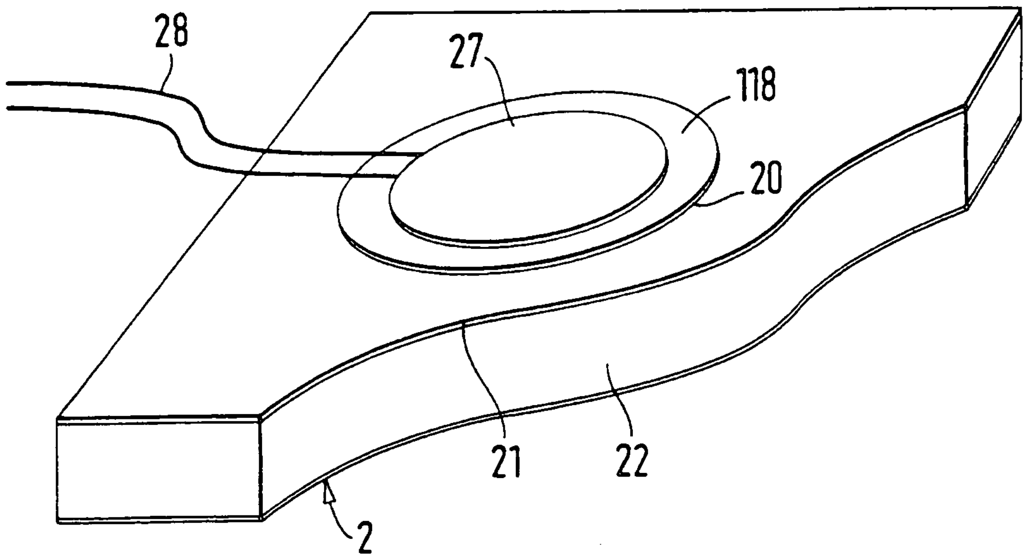


Fig. 24

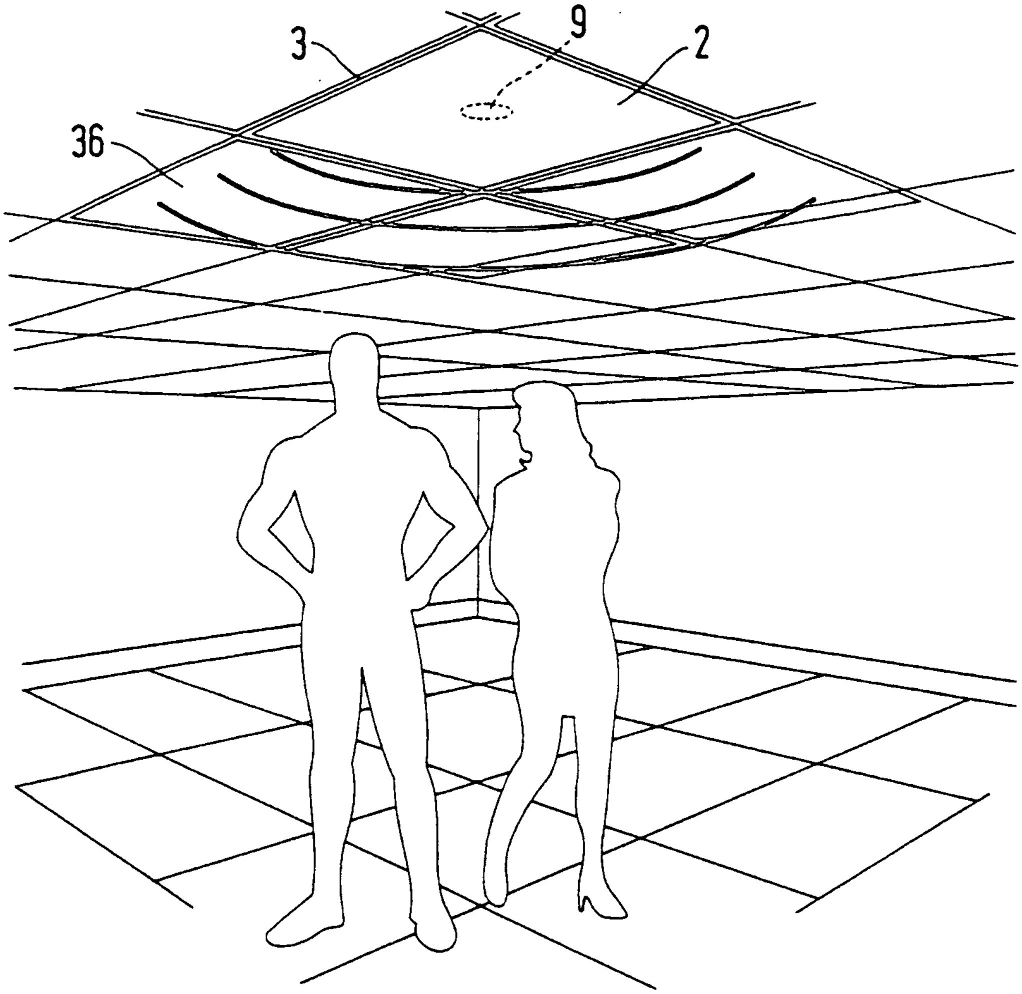


Fig.25a

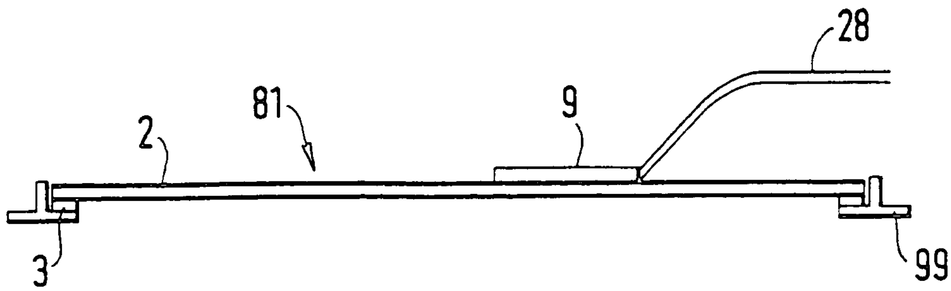


Fig.25b

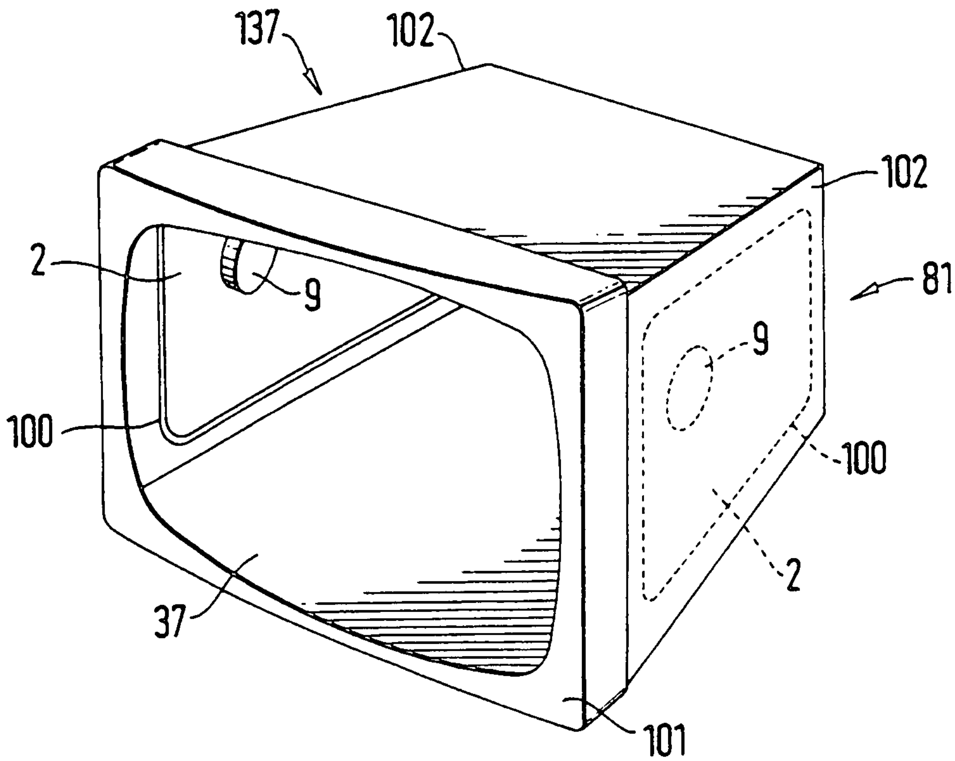


Fig.27

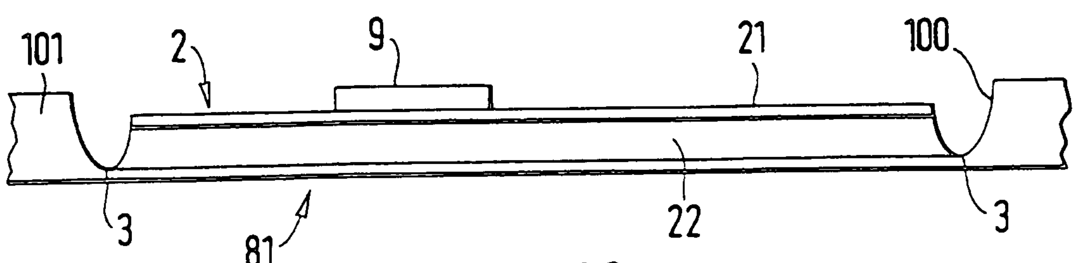


Fig.28

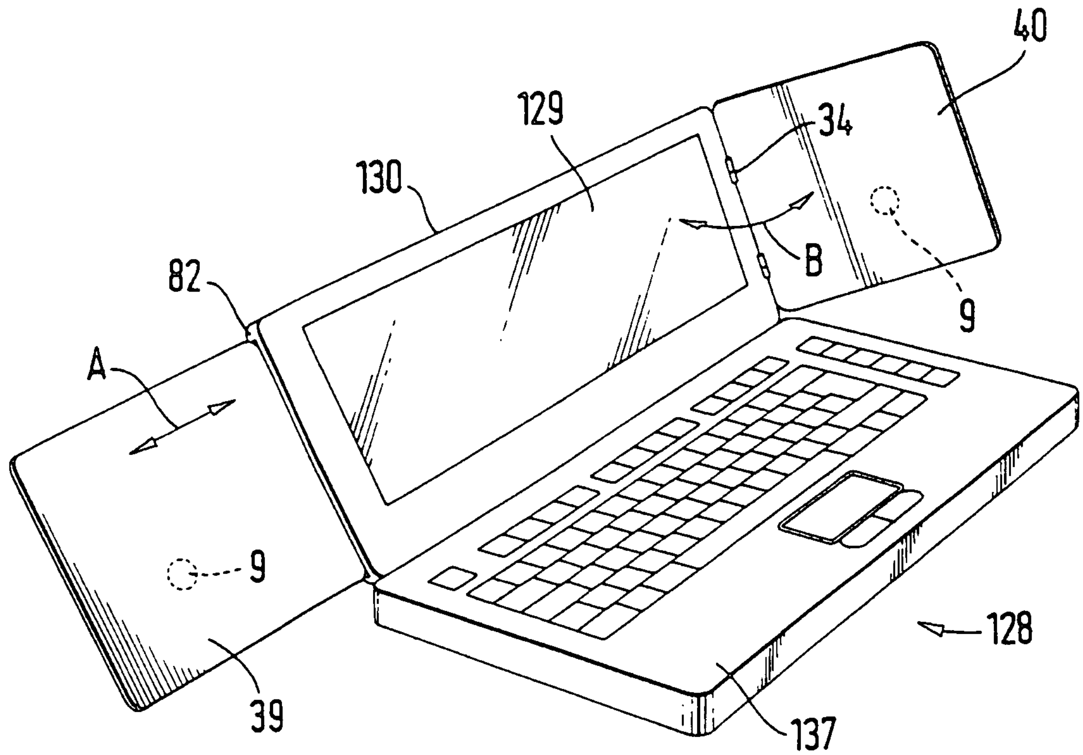


Fig.29

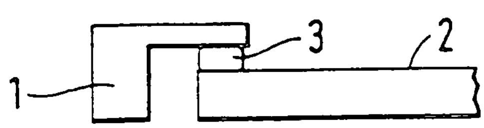


Fig.30

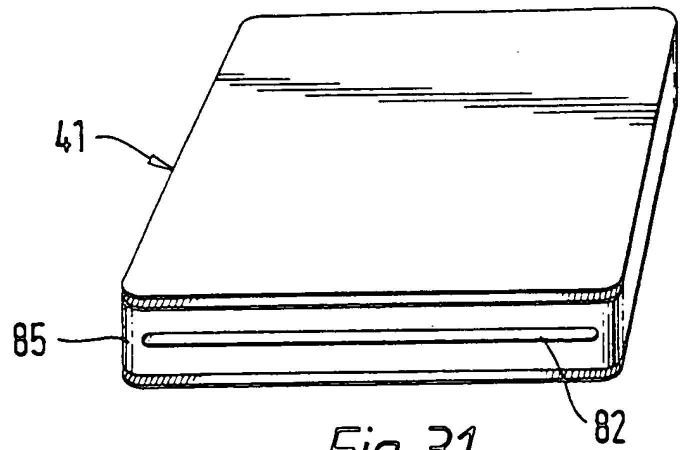


Fig. 31

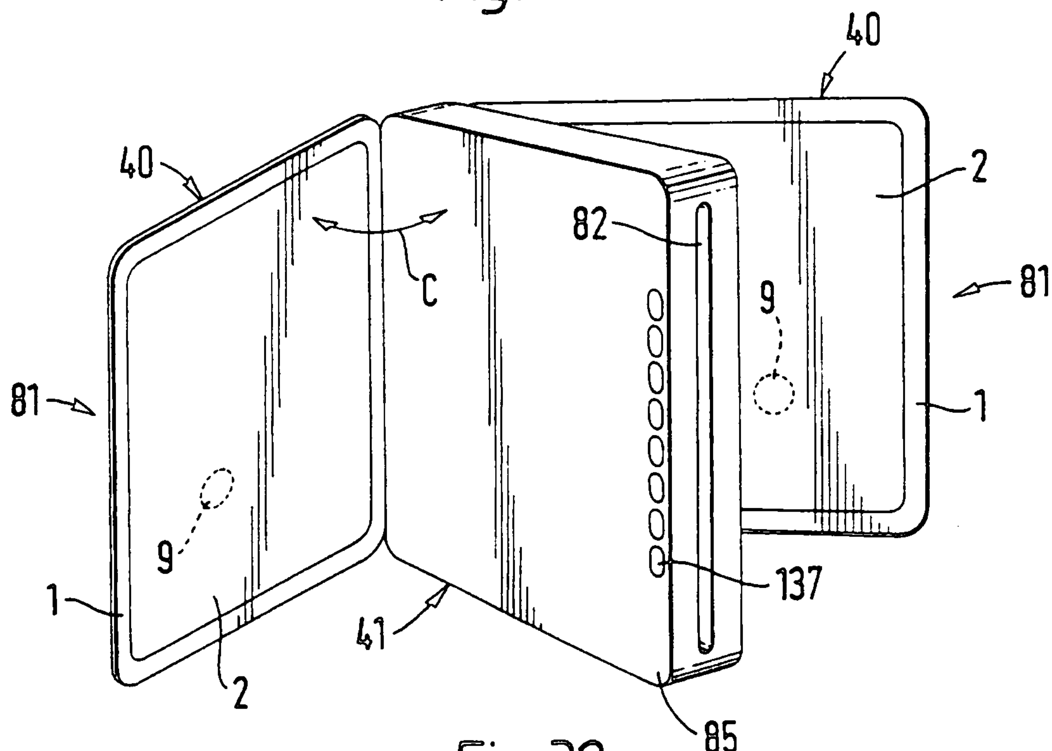


Fig. 32

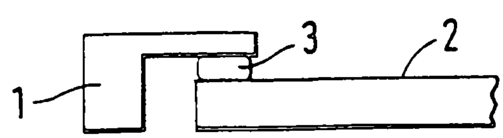


Fig. 33

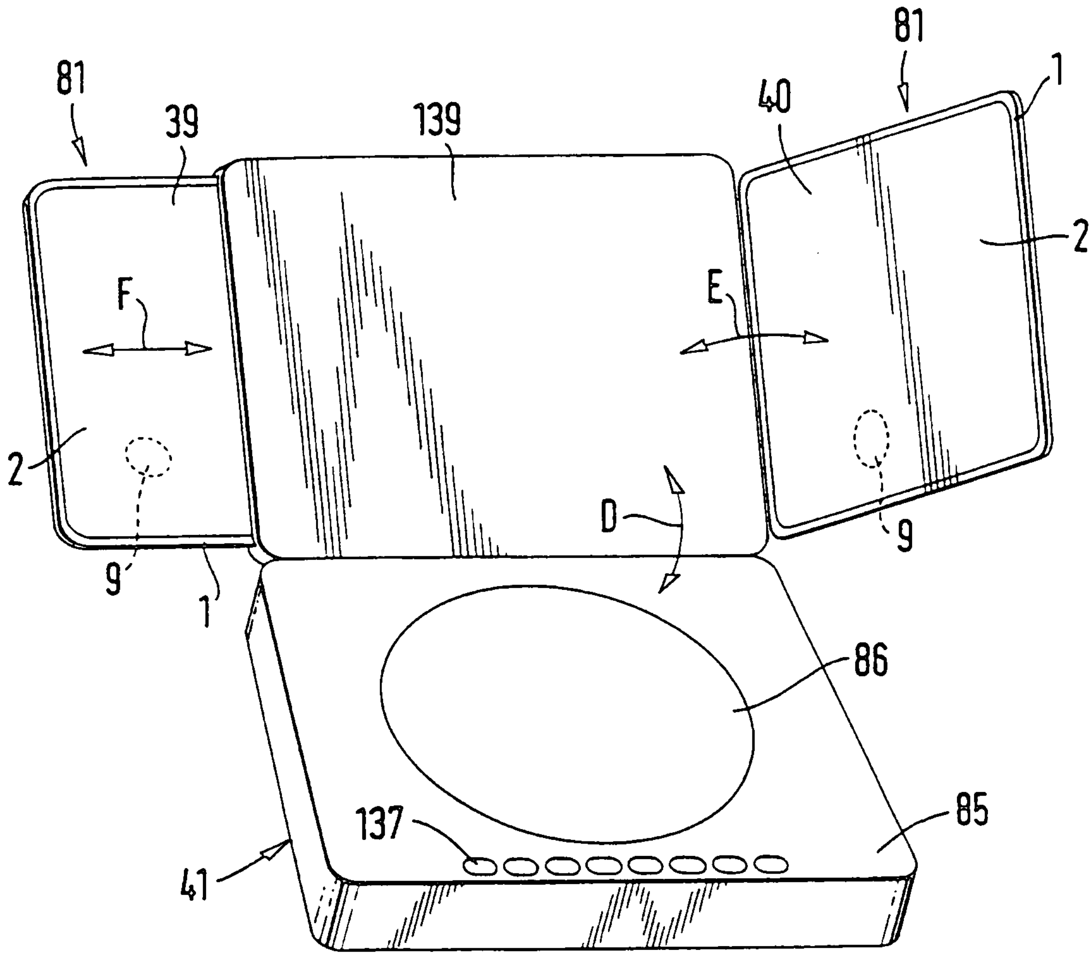


Fig.34

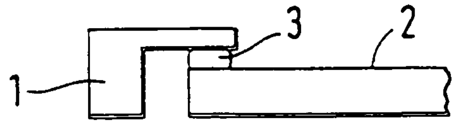


Fig.35

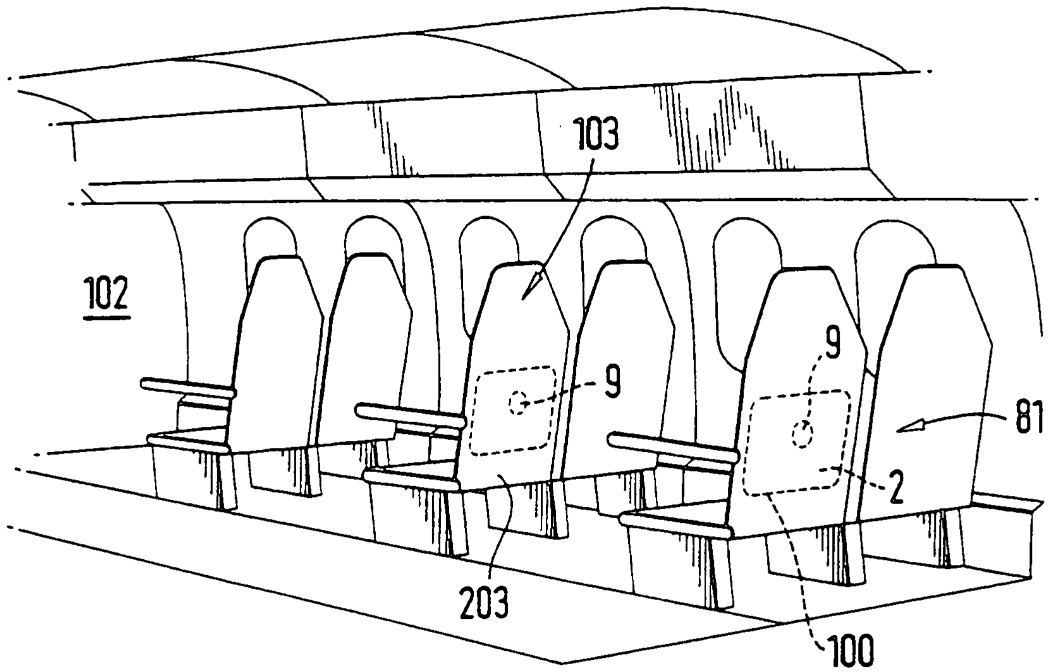


Fig.36

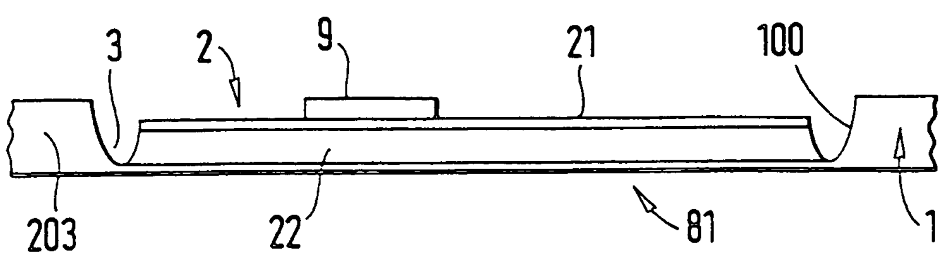


Fig. 37

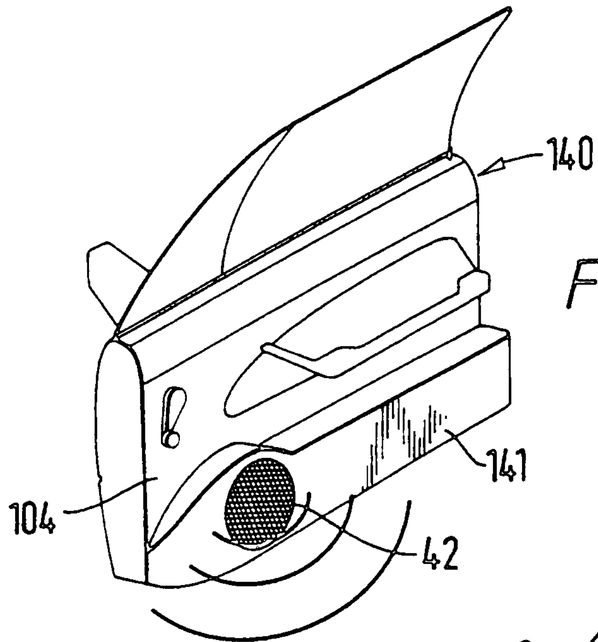


Fig.38

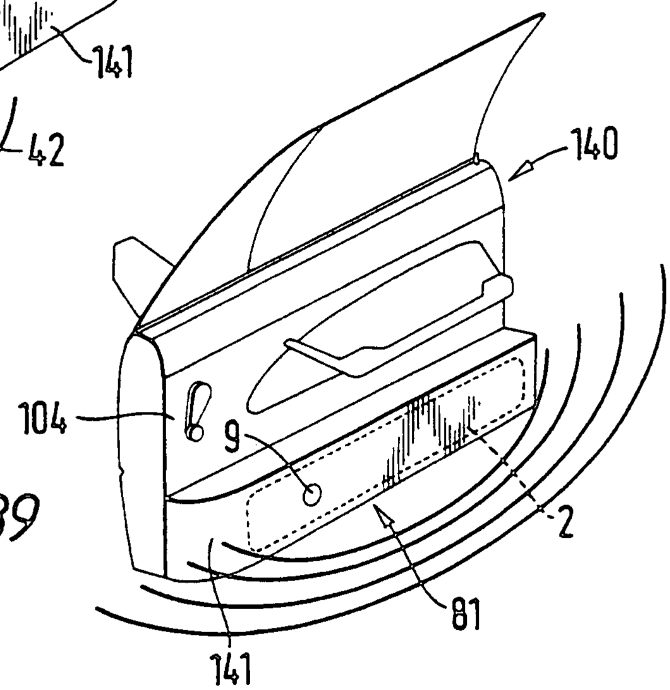


Fig.39

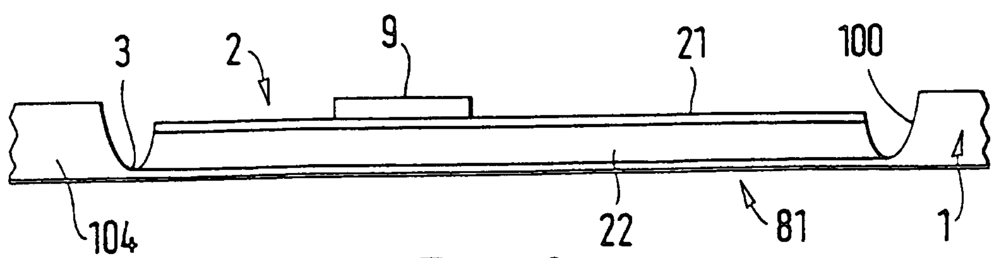


Fig.40

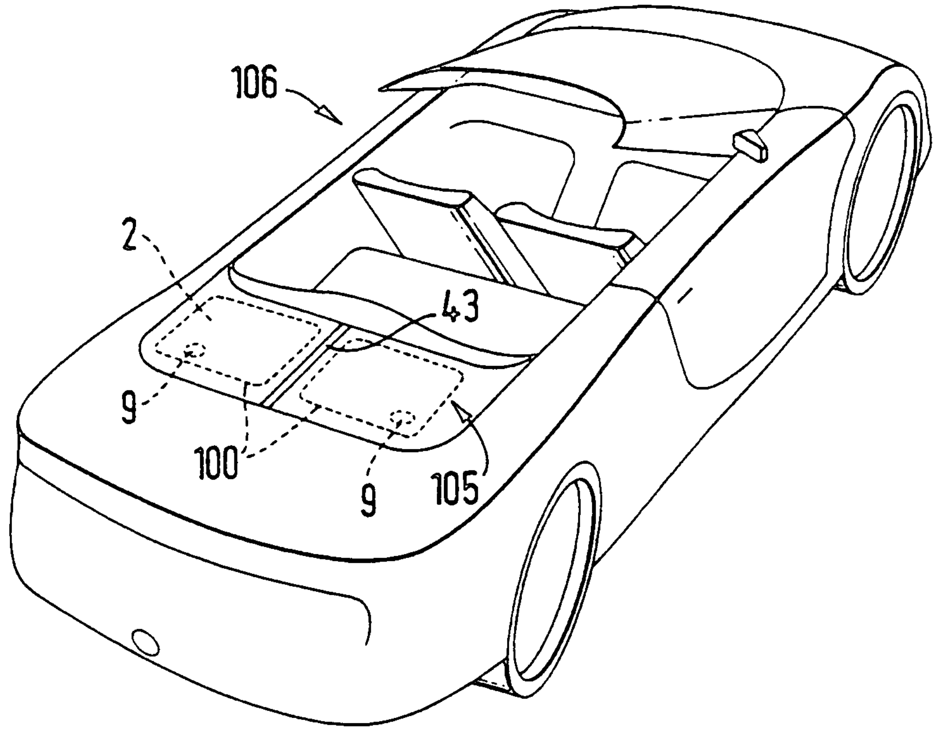


Fig.41

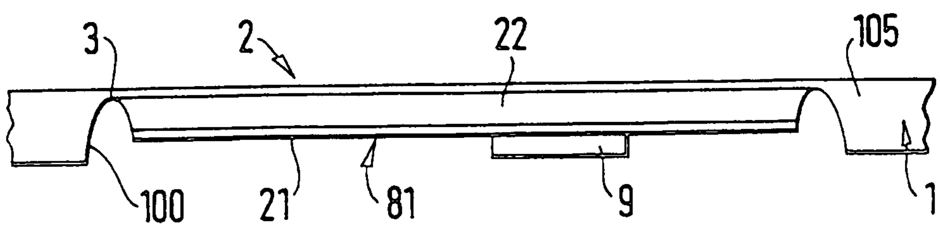


Fig.42

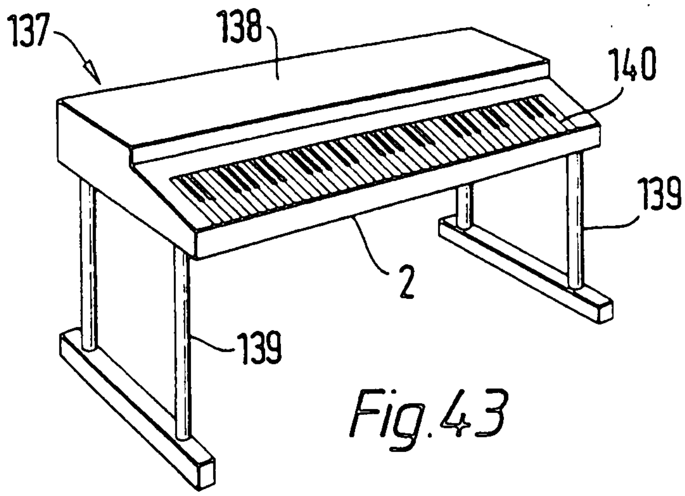


Fig.43

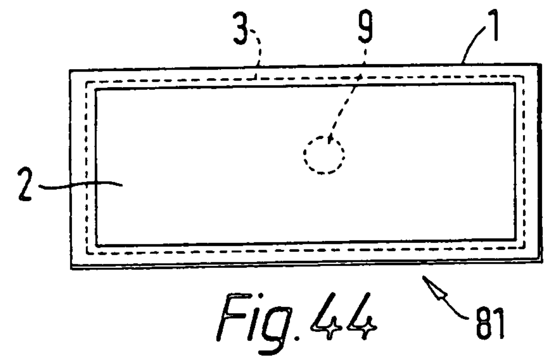


Fig.44

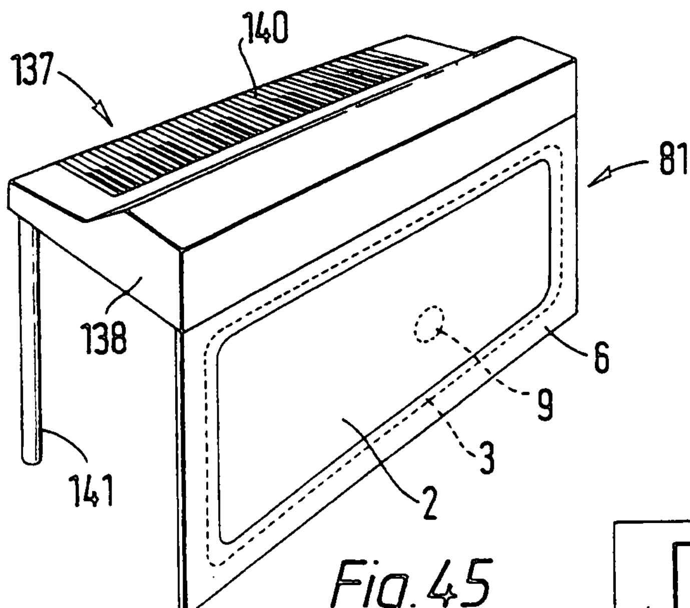


Fig.45

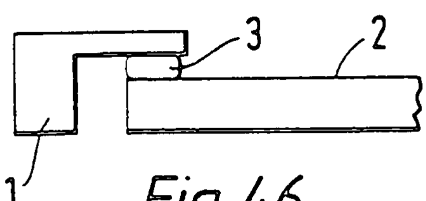


Fig.46

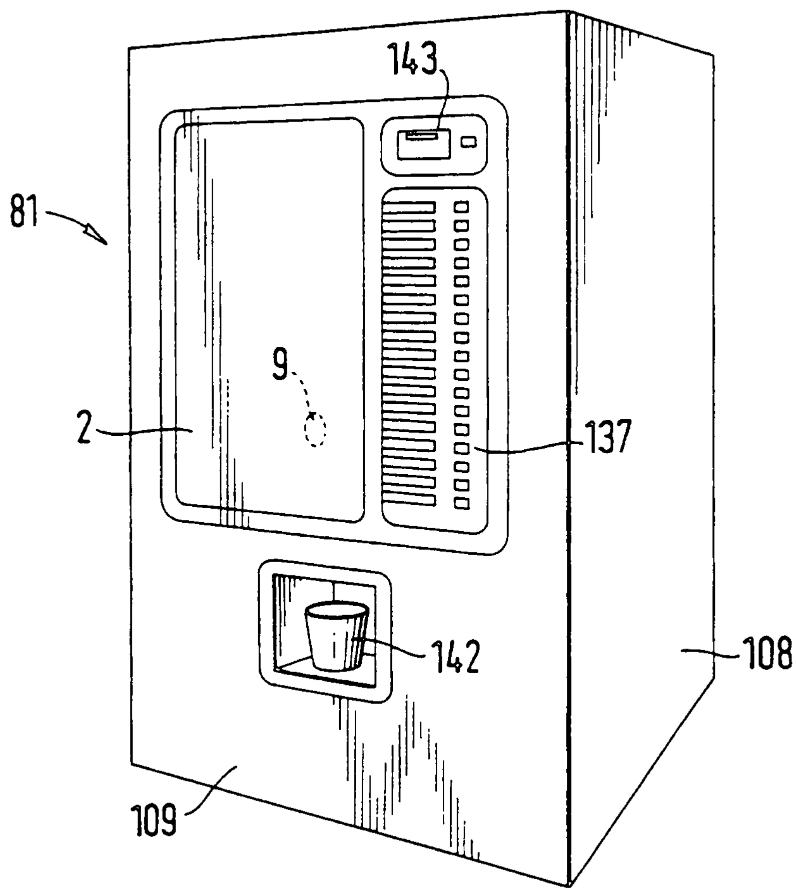


Fig. 47

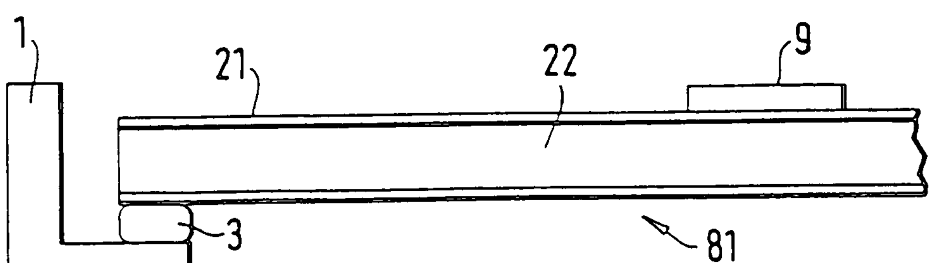


Fig. 48

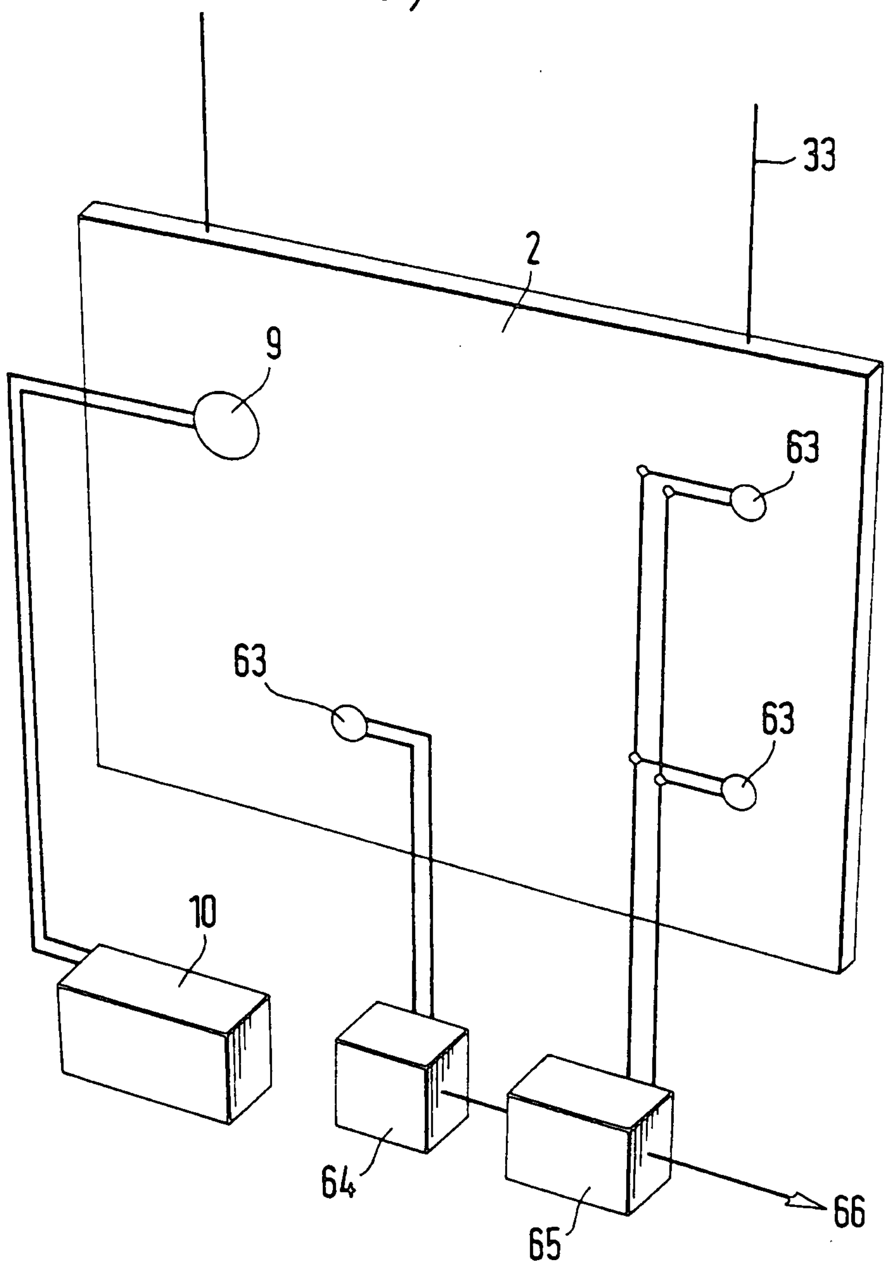


Fig. 49

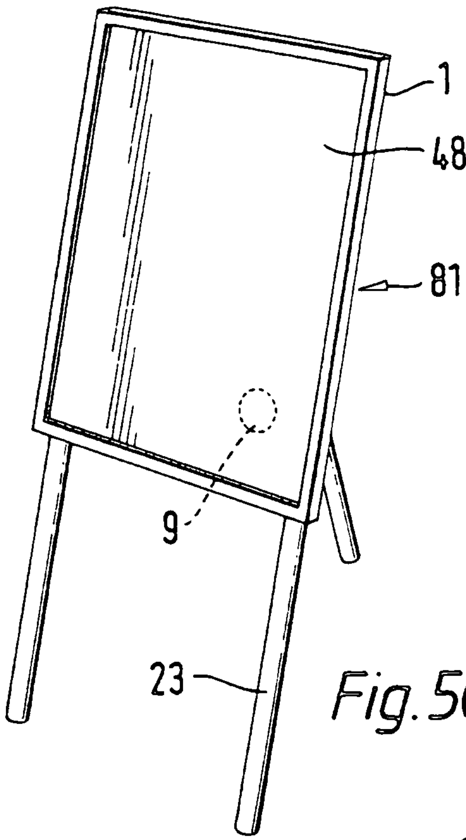


Fig.50

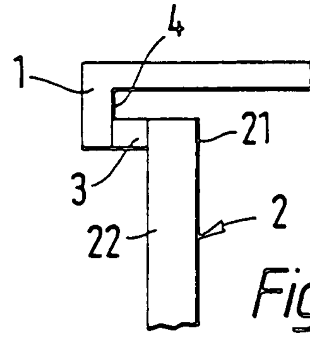


Fig.52

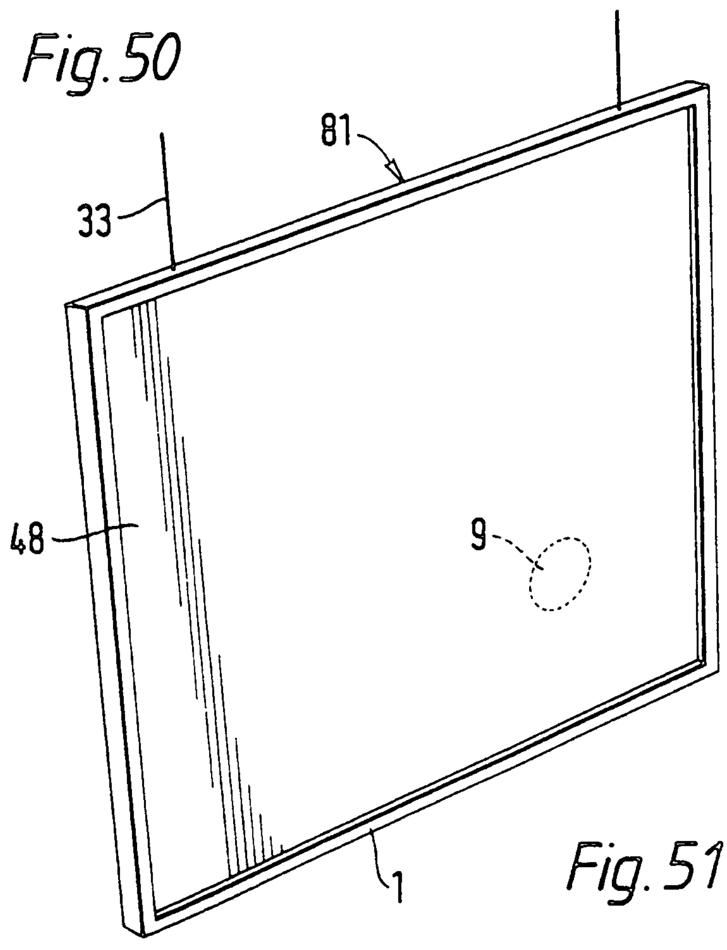


Fig.51

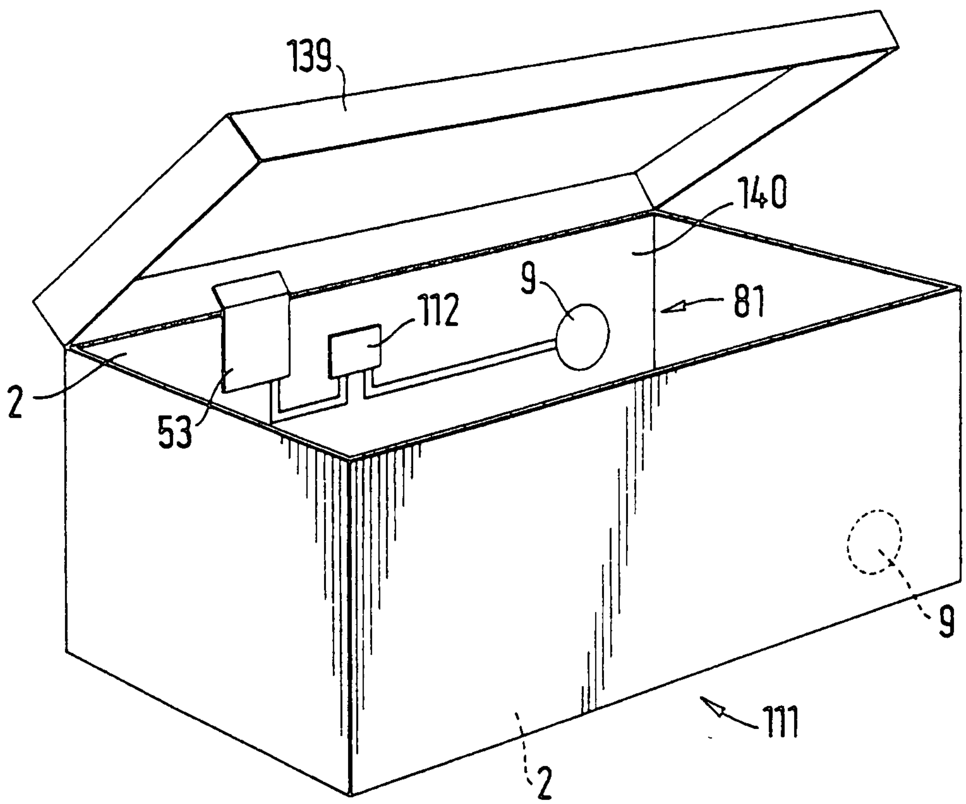


Fig.53

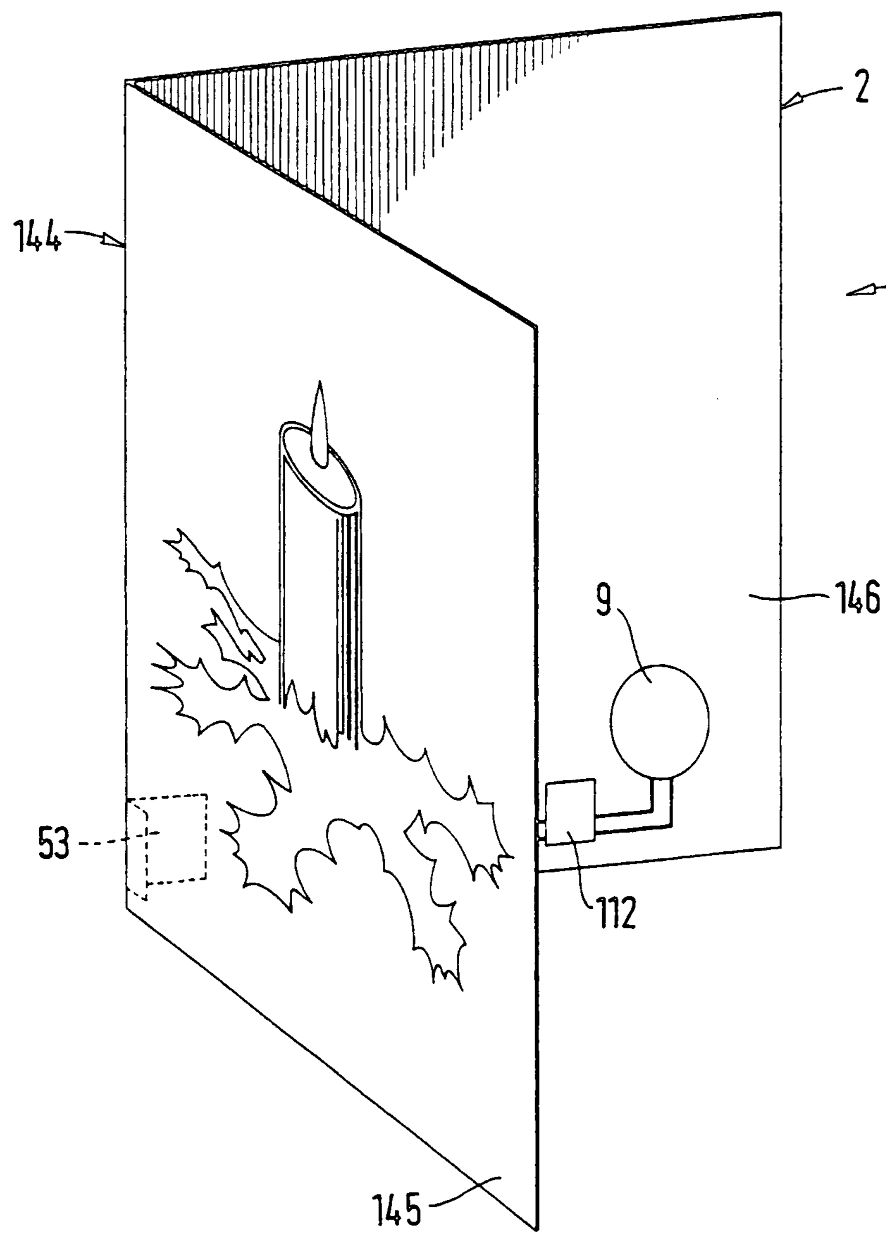


Fig.54

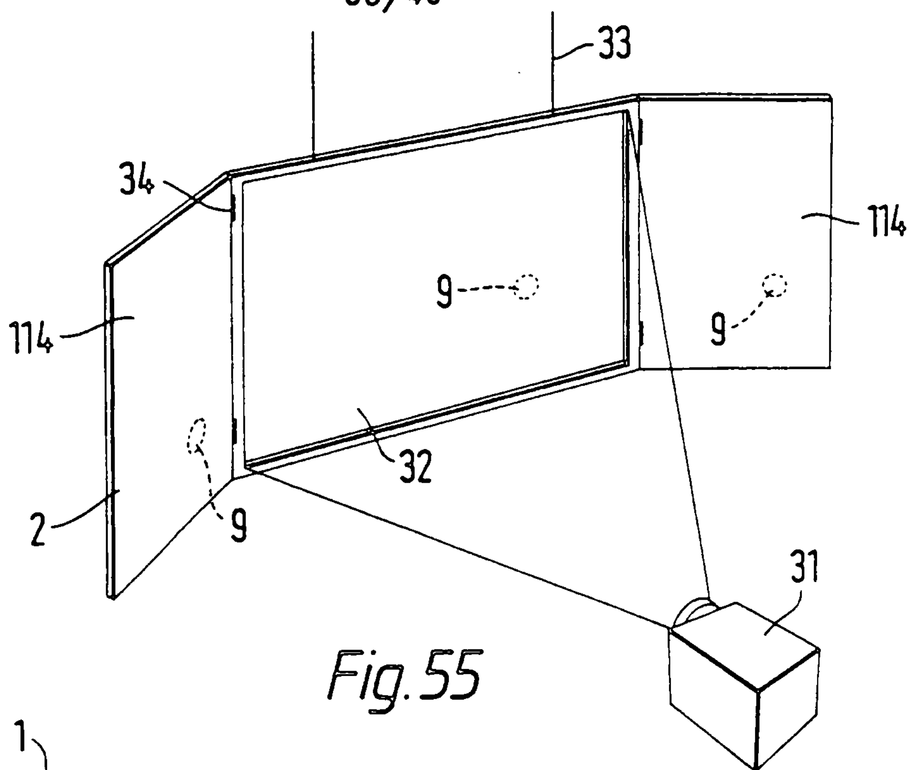


Fig.55

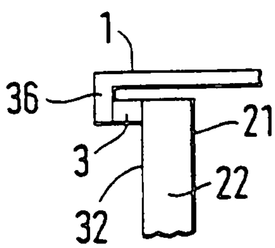


Fig.56

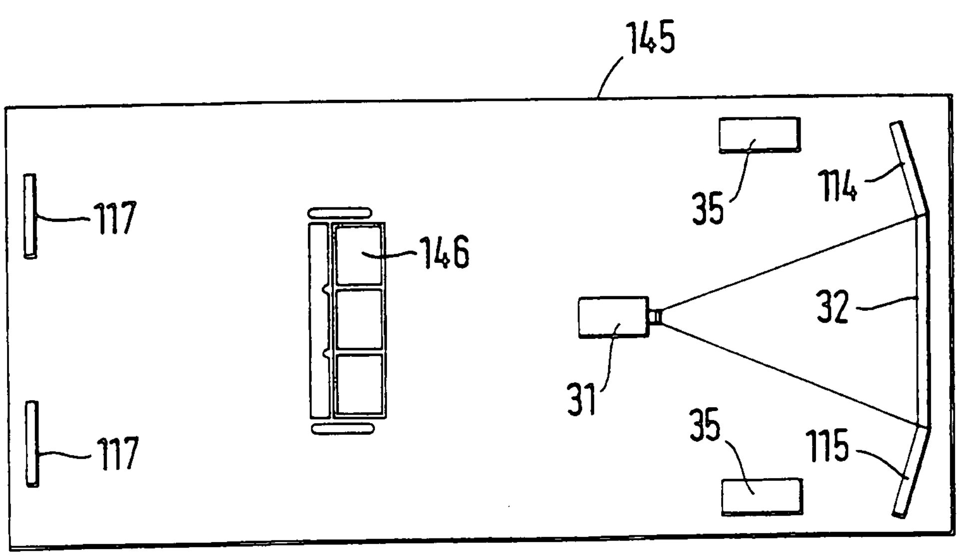


Fig.57

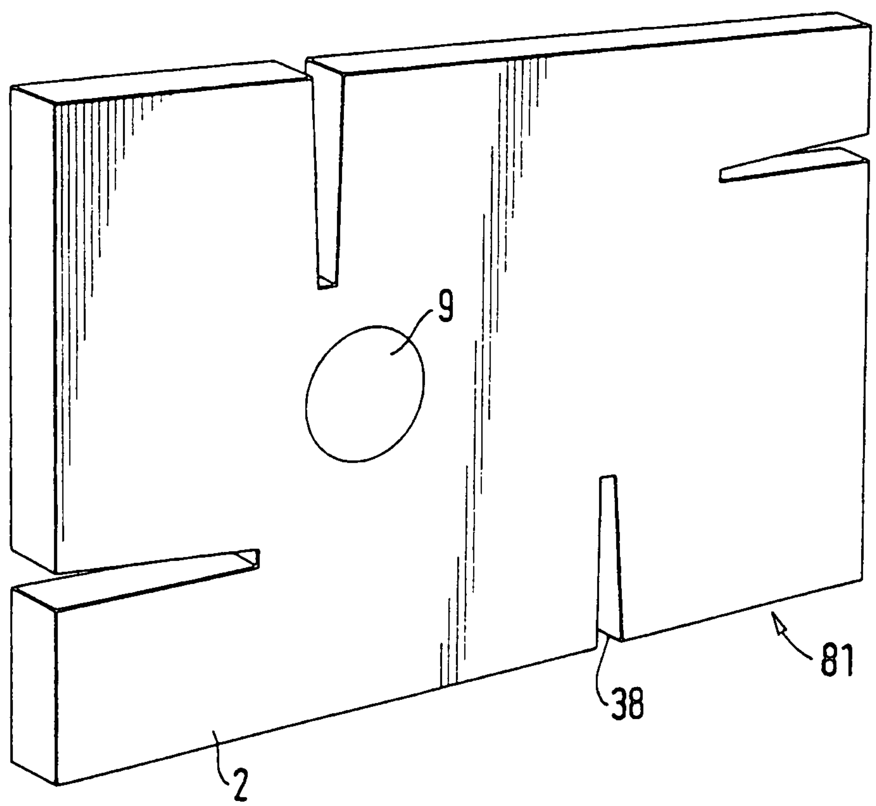


Fig.58

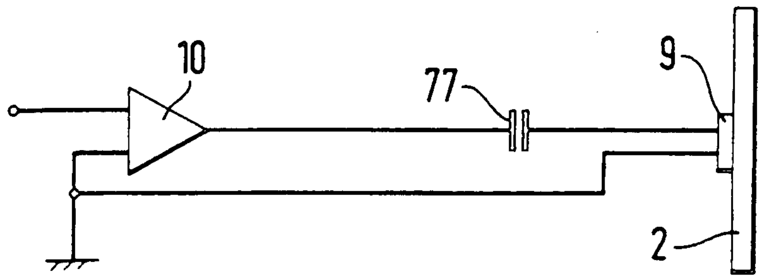


Fig. 59a

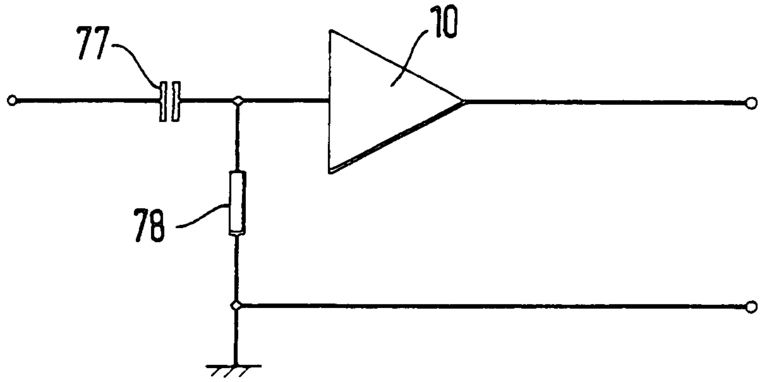


Fig. 59b

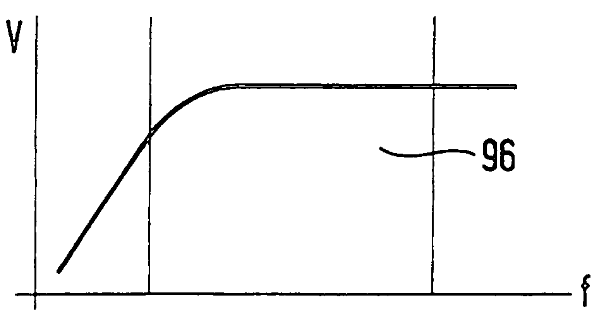


Fig. 59c

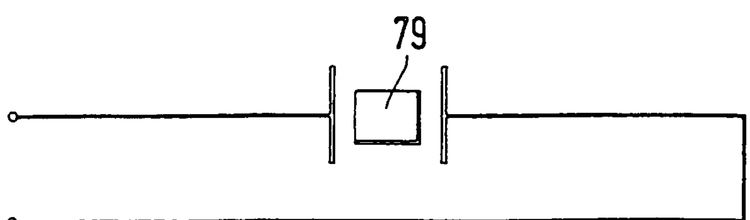


Fig. 59d

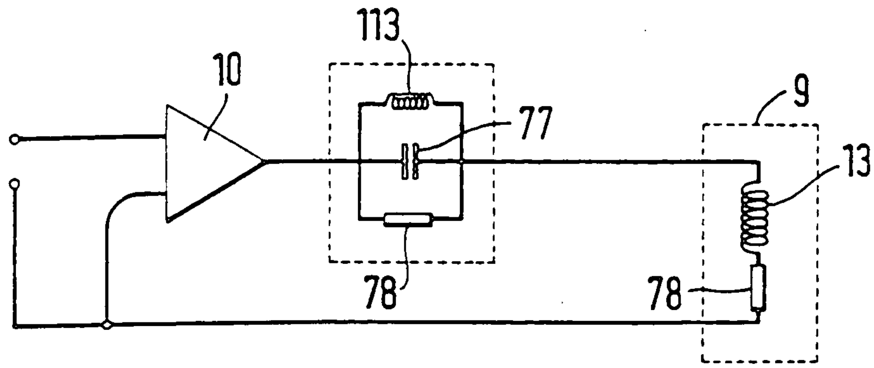


Fig.60a

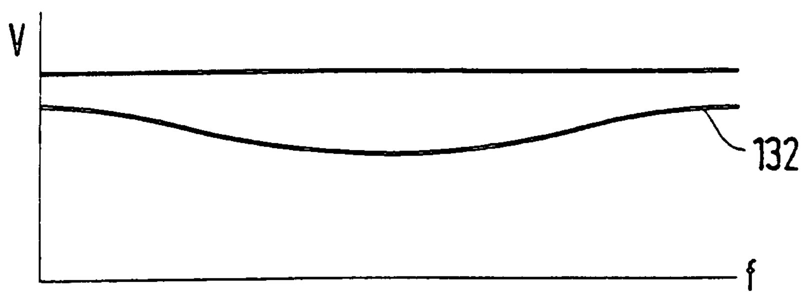


Fig.60b

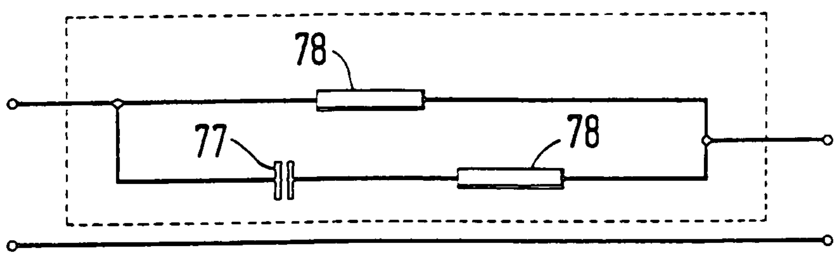


Fig.60c

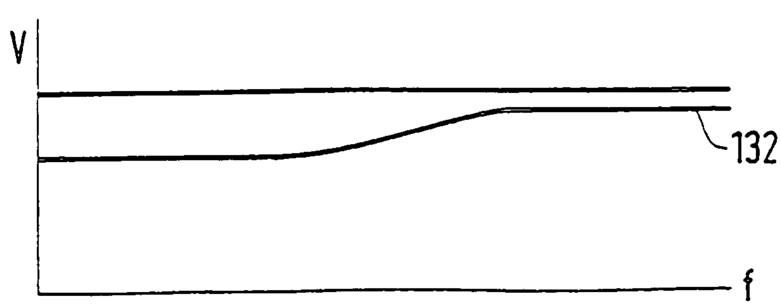


Fig.60d

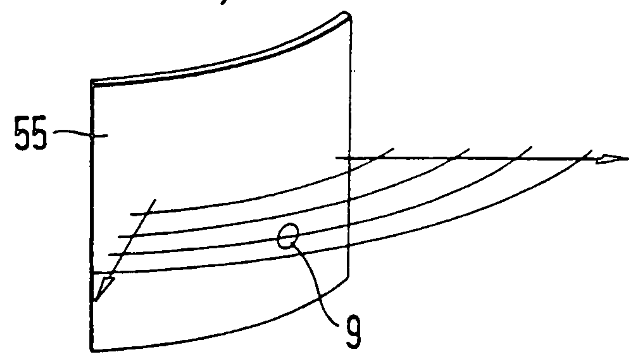


Fig.61a

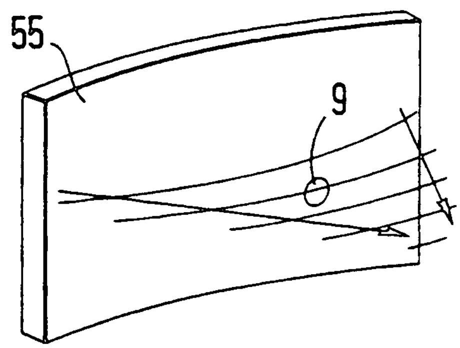


Fig.61b

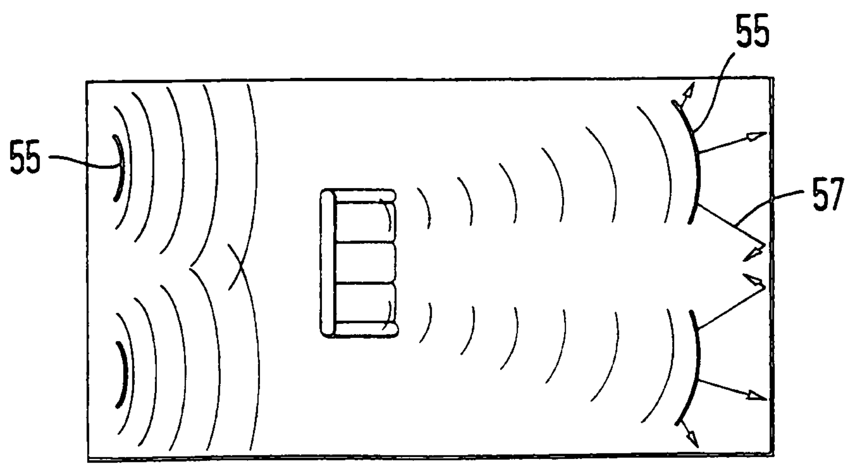


Fig.61c

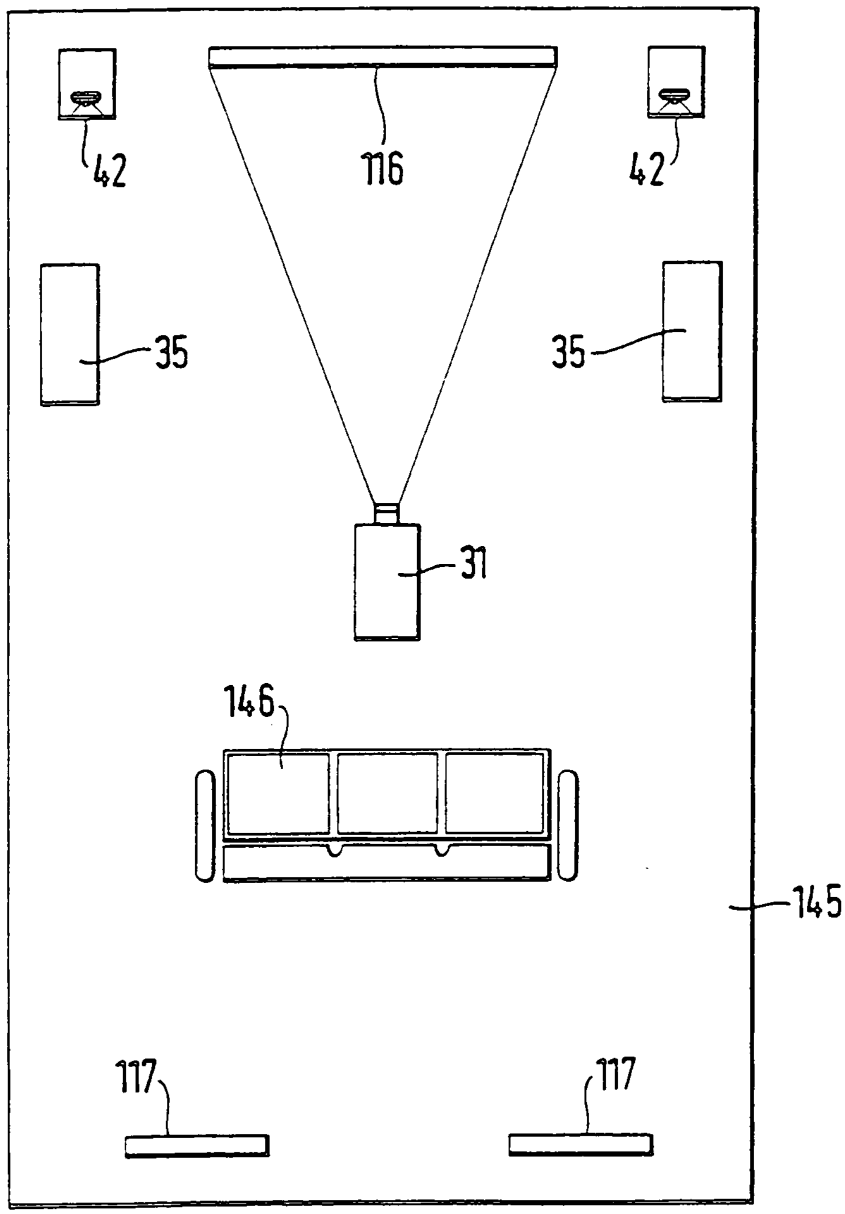


Fig. 62

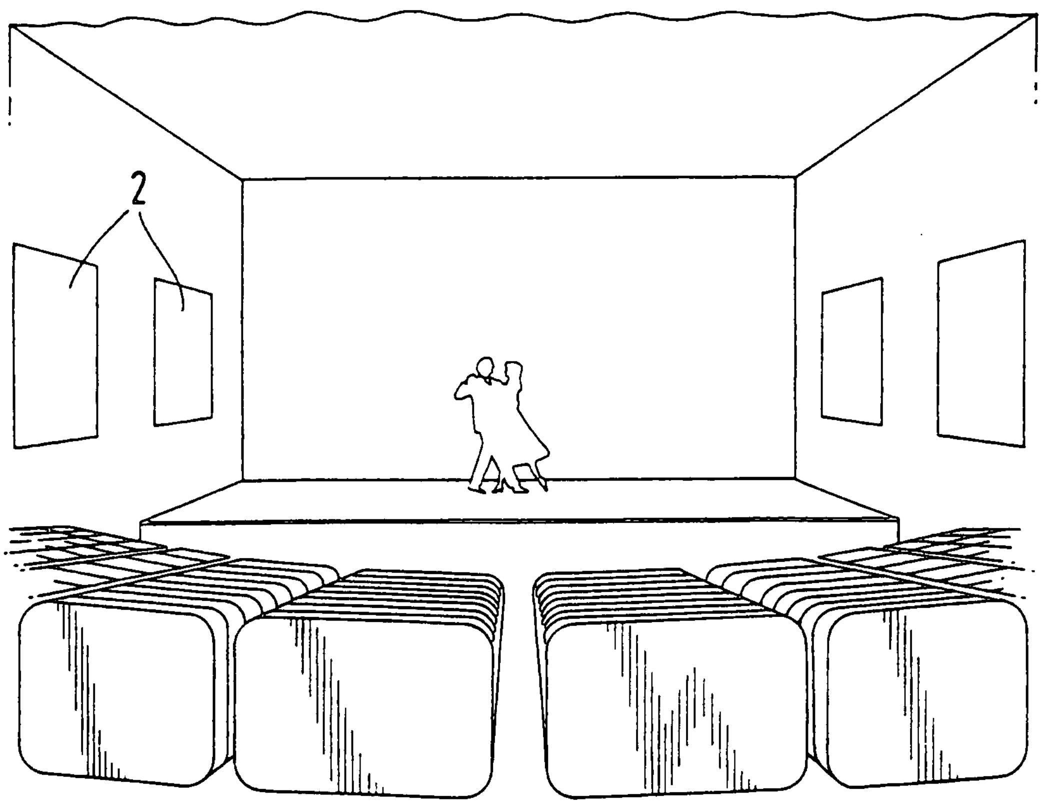


Fig.63

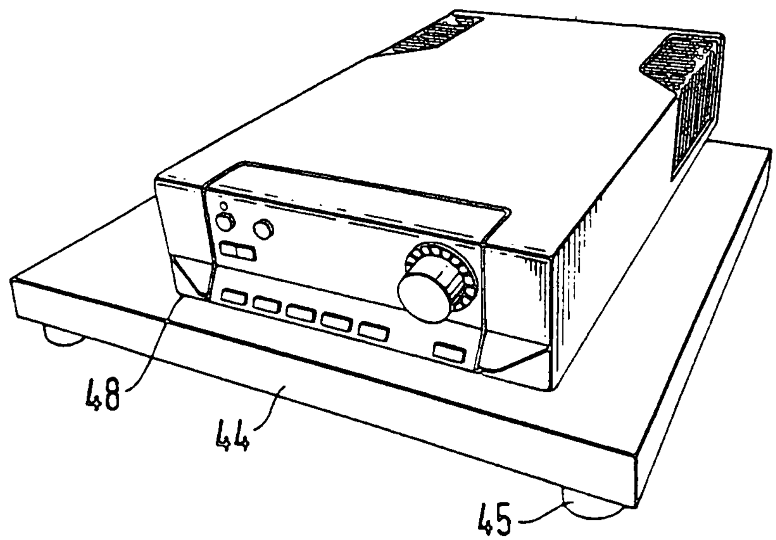


Fig.64

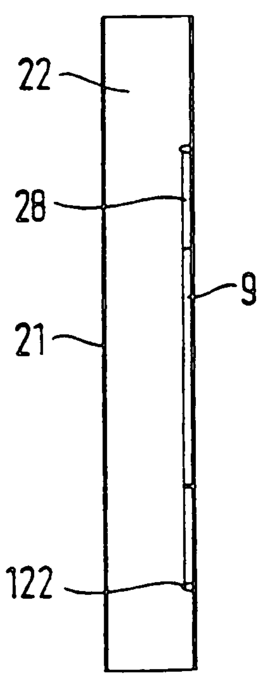


Fig.67a

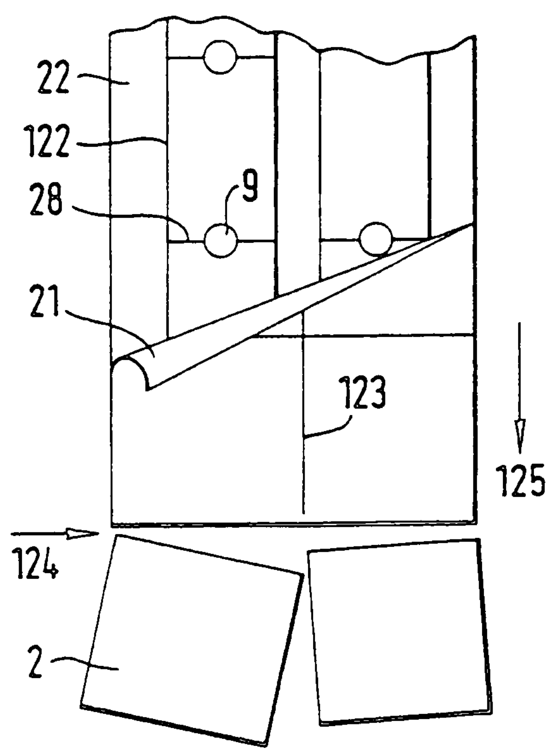


Fig.67b

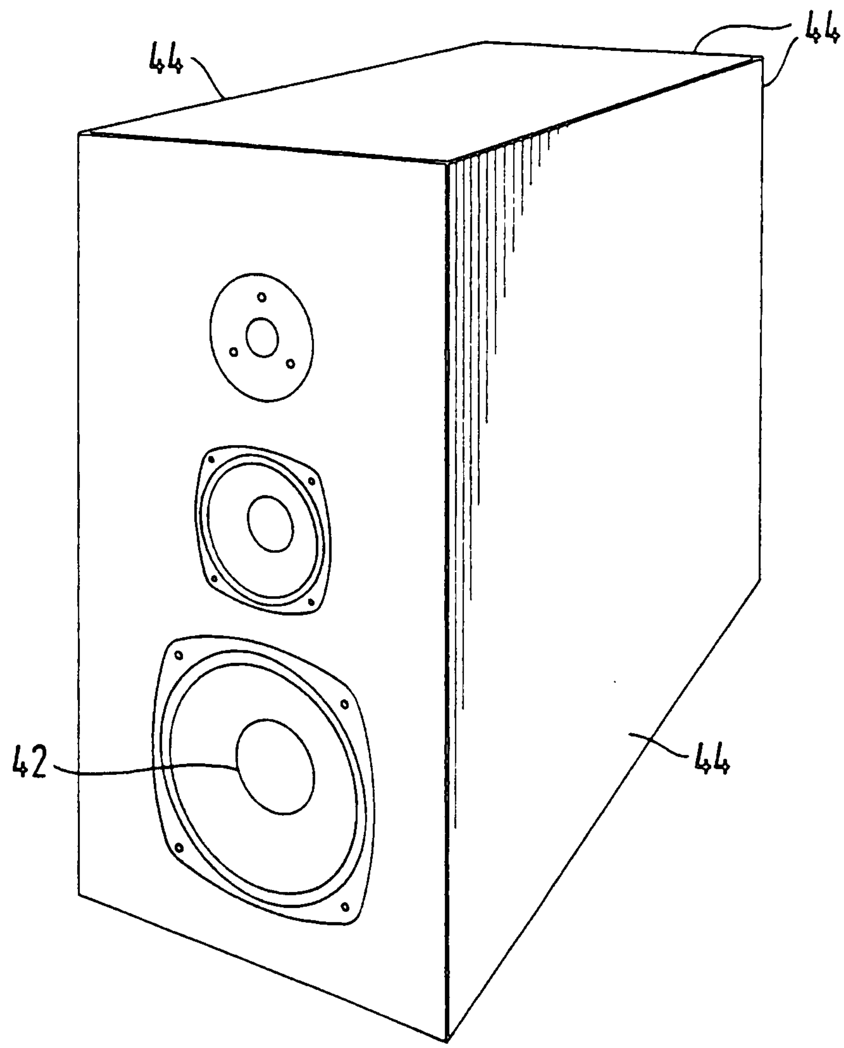


Fig. 65

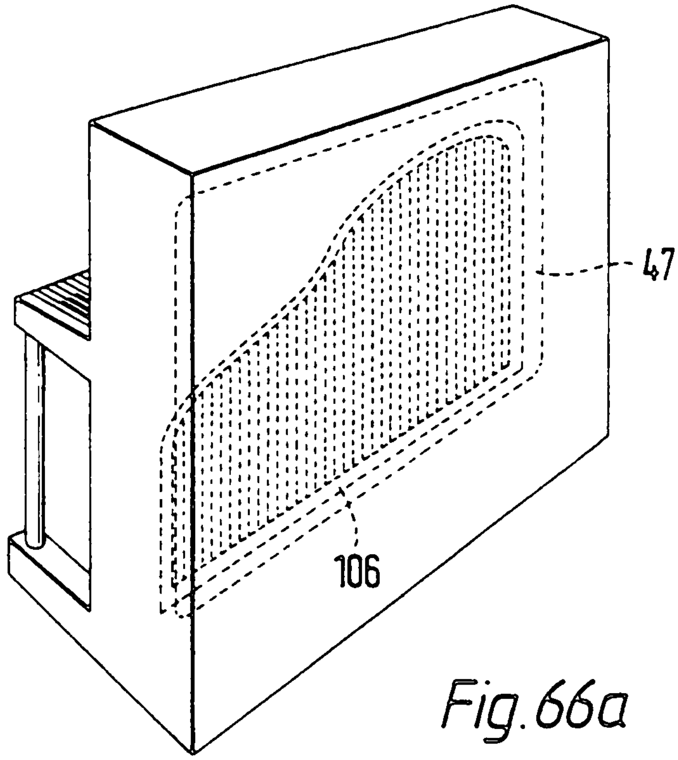


Fig.66a

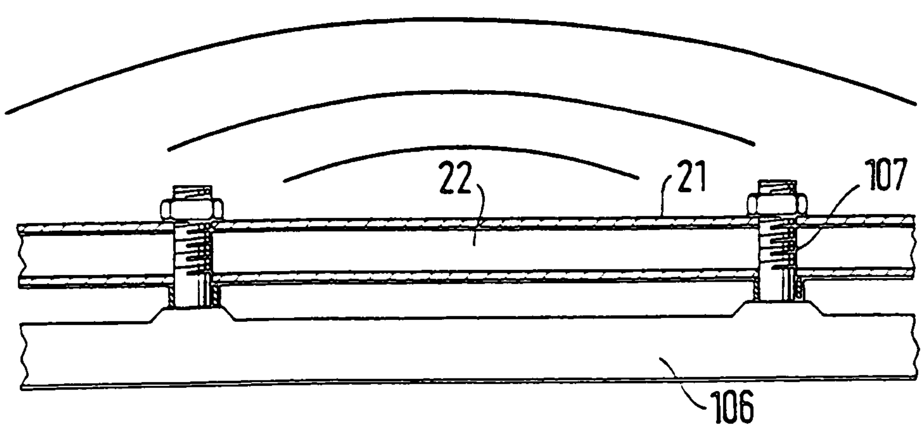


Fig.66b

INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 96/02145

A. CLASSIFICATION OF SUBJECT MATTER

IPC 6 H04R1/02 H04R5/02 H04R7/06 H04R9/06 H04R17/00
H04R1/42 H04N5/64 B65D79/00 G06F1/16 G10H1/32
G03B21/56 B42D15/02 G07F9/02 G09F27/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H04R

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 3 247 925 A (WARNAKA) 26 April 1966	1,2, 20-22, 52-54, 74,75
A	see column 2, line 55 - column 3, line 38; figures	3-19, 23-51, 55-72, 76-94
Y		73

Y	PATENT ABSTRACTS OF JAPAN vol. 007, no. 080 (E-168), 2 April 1983 & JP 58 008000 A (MURATA SEISAKUSHO:KK), 17 January 1983,	73
A	see abstract	

	-/--	

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
13 March 1997	29.05.97

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Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax (+31-70) 340-3016	GASTALDI G.L.

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Intern al Application No
PCT/GB 96/02145

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	GB 2 010 637 A (SONY CORP) 27 June 1979 see page 2, line 77 - page 3, line 78; figures ---	1
A	US 3 347 335 A (WATTERS ET AL.) 17 October 1967 cited in the application see column 1, line 13 - column 2, line 37; figures ---	1-94
A	WO 92 03024 A (SECR DEFENCE BRIT) 20 February 1992 cited in the application see page 5, line 4 - page 6, line 5; figures ---	1-94
A	US 3 422 921 A (WARNAKA) 21 January 1969 see column 1, line 20 - column 3, line 18; figures ---	1-94
A	US 5 333 202 A (OKAYA ET AL.) 26 July 1994 see column 4, line 47 - column 6, line 22; figures ---	1-94
A	SOVIET PHYSICS TECHNICAL PHYSICS, vol. 37, no. 3, 1 March 1992, pages 347-350, XP000335744 DREIDEN G V ET AL: "INTERFERENCE-HOLOGRAPHIC STUDY OF OSCILLATIONS OF HONEYCOMB DIAPHRAGMS" see page 347, left-hand column, line 1 - page 348, left-hand column, line 9; figures -----	1

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INTERNATIONAL SEARCH REPORT	International application No. PCT/GB 96/02145

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see extra sheets

1. ☐ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. ☐ As all searchable claims could be searches without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

1-94

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/210

Group I: claims 1-94 are directed generally to a method of making of or to an acoustic device including a member capable of sustaining bending waves, or to different embodiments thereof.

Group II: claim 95 is directed to a distributed mode acoustic radiator with a drive and a baffle.

Group III: claim 96 is directed to a distributed mode acoustic radiator with a supporting frame.

Group IV: claim 97 is directed to a distributed mode acoustic radiator with means for varying the air pressure .

Group V: claim 98 is directed to a distributed mode acoustic radiator with an inertial vibration transducer comprising resilient means.

Group VI: claim 104 is directed to a distributed mode acoustic radiator with two transducers.

Group VII: claims 105-106 are directed to a distributed mode acoustic member with sound sensor or microphone.

Group VIII: claim 107 is directed to a distributed mode acoustic radiator with suspended ceiling tile.

Group IX: claim 108 is directed to a distributed mode acoustic radiator with visual display unit and transducer means mounted wholly and exclusively on the radiator.

Group X: claim 109 is directed to a distributed mode acoustic radiator with lap-top computer and a transducer mounted wholly and exclusively on the radiator.

Group XI: claim 110 is directed to a distributed mode acoustic radiator with a portable compact-disc player and a transducer mounted wholly and exclusively on the radiator.

Group XII: claim 111 is directed to a distributed mode acoustic radiator within a vehicle and a transducer mounted wholly and exclusively on the radiator.

Group XIII: claim 112 is directed to a distributed mode acoustic radiator with a vehicle component and a transducer mounted on the radiator.

Group XIV: claim 113 is directed to a distributed mode acoustic radiator with an electronic musical instrument having a keyboard and a transducer mounted wholly and exclusively on the radiator.

Group XV: claim 114 is directed to a distributed mode acoustic radiator with a vending machine and a transducer mounted wholly and exclusively on the radiator.

Group XVI: claim 115 is directed to a distributed mode acoustic radiator with a notice board and a transducer mounted wholly and exclusively on the radiator.

Group XVII: claim 116 is directed to a distributed mode acoustic radiator with a packaging and a transducer mounted wholly and exclusively on the radiator.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/210

Group XVIII: claim 117 is directed to a distributed mode acoustic radiator with a greetings card and a transducer mounted wholly and exclusively on the radiator.

Group XIX: claims 118-121 are directed to a distributed mode acoustic radiator with a display screen card and a transducer mounted wholly and exclusively on the radiator.

Group XX: claim 100 is directed to an inertial transducer with plate-like piezo-electric bender.

Group XXI: claim 102 is directed to a transducer with a motor coil assembly and a magnet assembly comprising opposed disc-like pole pieces with a surrounding flange adapted to surround and to be disposed adjacent to the motor coil.

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